TU Delft

HOLLANDIA INFRA

MASTER THESIS

HOW INFORMATION FLOWS CAN BE ENHANCED IN CONSTRUCTION PROJECTS WITHIN CONSTRUCTION COMPANIES

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PREFACE AND ACKNOWLEDGEMENTS

This report is my graduation thesis on how information flows enhance coordination in construction projects within construction companies. This thesis was carried out as a graduation assignment for the master Construction Management and Engineering (CME) at the Delft University of Technology. Prior to this master I completed a bachelor in civil engineering and with this thesis my student life is concluded.

This graduation thesis would not have been possible without the supervision of my graduation committee, and therefore a tribute is in order. I would like to thank Marian Bosch-Rekveldt, being my first supervisor, for her time and dedication. Her feedback and insight on weekly basis have kept this research on track. I would also like to thank Mark de Bruijne, being my second supervisor, for his contribution during the progress meetings and providing personal feedback in the later stages. A tribute should also be payed to professor Hans Bakker for spending so much time correcting my report. His sharp feedback has moved me to think more deeply about the topics in this research.

I would also like to thank my company supervisor Hylco Jellema from Hollandia Infra for his time and dedication. Also especially offering a listening ear has helped me a lot during this process. Next to my company supervisor a big tribute goes out to all the people that participated in my Social Network Analysis and especially the ones that have been interviewed afterwards. Thank you so much for the time and energy. And last, but not least, the two experts who validated the conclusions.

Tom Oorschot
Delft, September 2021

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EXECUTIVE SUMMARY

The role of information flows increased over the last decades and has become more important within construction companies as they deal with complicated projects. Multiple recent studies state that enhancing the information flows can result in a better functioning organisation.

Research description

The information flow between the different layers of an organisation is of high importance. A distinction can be made between formal and informal information flows. Controlling a large organisation, the formal information holds a very dominant and strong position when it comes to information flows. Nevertheless, formal information does not always deliver the managers of the organisation the right information to establish proper coordination and strategy. Conjoining the process of acquiring information informally and the formal information systems of organisations has not been successful so far. The literature indicates that strategies and the way of coordinating an organisation should be based on both the formal and informal information, but chances are that the formal information instruments dominate the informal information. Hollandia Infra believes that there is room for improvement on how to cope with their information flows. The research question formulated in order to help to reflect upon this matter is:

'How can information flows be enhanced
in construction projects within a construction company?'

To answer this question a literature study is conducted to investigate the current theoretical role of information flows in intrafirm supply chains of construction projects. Afterwards a case study has been conducted at the construction company of Hollandia Infra. As part of this case study the intended information flow is studied by conducting a company document study. A Social Network Analysis is carried out in order to understand how the actual information flow functions. The intended and actual information flows are compared. Identified differences are explained by interviewing those involved. To understand the role information flows play in the organisation. The interview findings result in managerial implications which aim to support efforts to enhance the information flows. These managerial implications are validated by interviewing two experts.

Theoretical role of information flows

Information flows can be divided into formal and informal information flows. Formal information flows concern information that is less dependent on individual information holders. This form of information flows is easier to regulate, using IT systems for instance, than informal information flows. The informal information flow is very dependent on the individual information holder and his/her willingness to share information. The focus of organisations is mainly on the transfer of formal information as organisations aim to provide and produce generic information and guidelines that employees can use to work with. This results in informal information flows playing a background role, while this form of information is of strategical added value.

Intended and actual information flow

By carrying out a company document study, the primary process of Hollandia Infra during the construction phase was studied in-depth. Understanding and visualising the workflow and what the function of the different actors in the primary process is, has led to the disclosure of the relationships and the associated information flow. Based on the process schemes of Hollandia Infra it can be

assumed who is in contact with whom and thus how the information is intended to flow through the organisation.
The actual information flow of Hollandia Infra was investigated by carrying out a Social Network Analysis, which provides insight in which contacts actually happen. The Social Network Analysis was performed using the method of Cross, 2010. The advantage of this method is that it also shows the status of the relationship using four dimensions: frequency, responsiveness, effectiveness and energy. This method was extended by adding two implicit coordination related factors, namely *the willingness to* share and *task interdependence.* Studying the results of the Social Network Analysis and mapping which actors are in contact with whom, has led to the actual information flow.

Comparison intended and actual information flow
Comparing the intended and actual information flow led to the identification of absent and unforeseen contacts. Next to this, a quantitative analysis on the centrality scores of the actors showed a significant difference between the intended and actual information flow in the centrality score of the project manager. The quantitative analysis also shows that the manager of fabrication is the most central actor in the intended information flow as well as in the actual information flow. Interviewing those participants involved, has provided data that shows that the project manager desires to have more contacts with the workforce in the installation hall, however he fails to do so as he has no time available. The interview findings also showed that the informal information flow plays a crucial part in the organisation and helps filling the gaps in the formal network. Studying the interview findings, ten managerial implications were created in order to enhance the information flows.

Enhancing information flows
This study showed ten managerial implications for Hollandia Infra divided into three clusters, namely: staffing, formal process and investments. To answer the main research question of this study, these three clusters will be used to provide the answer.

Staffing
This study also revealed that communication between the production hall and the office is of great importance. Neglecting this communication between the construction hall and the office causes a shift in the information flow, leading to changes in the formal process and thus the central positions of actors. In addition, it is important for the project management to be in close contact with what is happening in the production halls. Otherwise they run the risk of getting out of touch with the project.

Formal process
It is very important that all actors in the network are aware of each other's function. This is not always the case, which means that the actors are not able to provide each other with the correct information. It is important for organisations that every actor is well aware of the function of another actor. This ensures that everyone understands who benefits from which information.

Investments
This study found that there is a discrepancy between formal and informal information flows. The informal information flows help to close the gaps in the formal intended information flow. Observing the importance of the informal information flow, companies should address the role the informal information flow should have in their organisation. Organisations need to invest in creating a balance between the formal and informal information flows and the role they should fulfil.

Recommendations to Hollandia Infra

This section shows the recommendations made to Hollandia Infra based on the results of this research.

Enhancing the information flow

Hollandia Infra is advised to apply and focus on the three most important managerial implications in order to enhance the information flow, which are:

- MI01: The project manager must maintain frequent contact with the workforce in the production hall.
- MI02: The role of manager of fabrication must be less central in order to prevent a burn out.
- MI09: Invest in creating a balance between the formal and informal information flows and the role they should fulfil.

In order to help enhancing the information flows within a construction project within a construction company, these three managerial implications are deemed to be applied.

Recommendations on future research

This research suggests five recommendations on future research:

- Application of implicit coordination related factors;
- Further elaboration of the method of Cross et al, 2010;
- Address the role informal information flows should have;
- Studying modern technology systems concerning formal information flows;
- Take individual cultural backgrounds into account.

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LIST OF ABBREVIATIONS

ASM	:	Assembly manager
CM	:	Construction manager
CME	:	Construction management and engineering
DE	:	Design engineer
DEM	:	Design and engineering manager
DIR	:	Director
DRDE	:	Draught design engineer
DRE	:	Draught engineer
FABM	:	Fabrication manager
FO	:	Foreman
FOG	:	Foreman General
HILS	:	Hollandia Infra leadership school
HIN	:	Head of installation
ILE	:	Installation leader
LGF	:	Logistic foreman
LGM	:	Logistic manager
MFAB	:	Manager of fabrication
MI	:	Managerial implication
MSHEQ	:	Manager SHE & quality
PE	:	Project engineer
PN	:	Production engineer
PL	:	Planner
PM	:	Project manager
QCE	:	quality engineer
QCI	:	Quality controller
SM	:	Sight manager
SNA	:	Social network analysis
SUP	:	Supervisor
UITV	:	Performer

1 INTRODUCTION

1.1 BACKGROUND: INFORMATION FLOWS IN CONSTRUCTION PROJECTS

As time goes by, the role of information becomes more important within organisations. Companies need to adjust to new innovations to stay up to date (Utterback, 2009). A lot of these current innovations initiate ways to improve the way information is dealt with. The way the information is structured is of great importance for companies since this helps to create a proper flow of information (Barwise et al, 1997). How information is structured and provided to different layers of an organisation is important for the efficiency as well (Burn, 1989). The concept of *information flows* is a broad term and therefore needs specification. Within organisations two different types of information flows can be recognised, namely formal and informal information flows (Macdonald, 1992). Formal information concerns information that is available for all individuals within the organisation for whom the information is intended, such as construction drawings or product descriptions (Barmeyer, 2019, p. 797). Informal information, in contrast to formal information, is fully dependent on individuals (Liu & Milanova, 2010). In organisations it is very common and accepted that formal information is supplemented with comments, suggestions or ideas, which is technically informal information (Soda & Zaheer, 2012). In other words, the informal information flow often supplements the formal information flow, but it is difficult to regulate.

In practice, it can therefore occur that the actual information flow turns out to be quite different from its initial design (Braha & Bar-Yam, 2004). The mutual communication between people within organisations is often not evenly distributed and only a handful of people with a strong communication network actually control the entire informal information flow (Hickethier et al, 2013). Back in the day, not the information flow but the physical flow of goods and products dominated the design decisions that were made (Lewis & Talalayevsky, 2004). However, the intra-organisational structure may be more likely to be controlled by the flow of information than by the physical flow (Huber, 1984; Laudon & Laudon, 2019). In other words, improving the information flows of an organisation may result in the realisation of a more advanced coordination, which is essential for effective project management (Chiocchio, 2007; Day et al, 2009).

Coordination, just like information flows, is a broad concept. An organisation consists of activities that often depend on each other (Malone & Crowston, 1994). According to Malone and Crowston, coordination can be defined as the process of managing these mutual dependencies. It is of course the case that an organisation does not consist of just one activity, but of several. Given the definition of coordination, it seems obvious that different dependencies are in need of different coordination processes. A study carried out by Thomas Malone, shows three different coordination domains, one of which was about the need to understand the unavoidable effects the flow of information has on an organisation (Malone & Crowston, 1994). Almost all of the different coordination processes rely on the input of information, of which the largest part consists of formal information (Diaconescu et al, 2021). For instance, logistics coordination is a coordination structure that relies heavily on the input of information (Lewis & Talalayevsky, 2004). The information flows are dominated by formal information, but informal information flows may sometimes hold needed information (Soda & Zaheer, 2012), and may therefore may be of more influence than is originally thought.

This research aims to understand how information flows can be enhanced in construction projects within construction companies. To achieve this, a case study is conducted at an organisation called Hollandia Infra.

Hollandia Infra is one of the larger Dutch companies in the market for steel infrastructure objects and is mainly active in the manufacturing of steel bridges, lock gates and flood defences. These products are typical engineer to order products, which are produced on a project basis. One can imagine that producing these large steel infrastructure objects requires good management and a well-developed flow of information through all levels of the organisation. Given the fact that Hollandia is responsible for the engineering, constructing, placing and often the maintenance of the project, the information flow between the different phases of the projects is of high importance. Hollandia Infra is an organisation that aims to improve their way of distributing information.

1.2 PROBLEM DEFINITION

This section breaks down the problem that stands at the heart of this study. This is done from two perspectives. The first perspective describes the problem from a theoratical perspective and the second perspective describes the improvement that Hollandia Infra needs.

1.2.1 Problem from a theoretical perspective

Due to the increasing role of information related innovations the complexity of today's projects is ever increasing. One of these information related innovations relates to coordination, which comes down to organising the coherence between activities (Malone & Crowston, 1994). Coordination is essential when striving for good team performance and successful and efficient project management (Chiocchio, 2007). This is partly due to the fact that coordination is connected to the level of communication and mutual relationships. Coordination occurs whenever communication between people takes place and decisions are being made (Lewis & Talalayevsky, 2004), and therefore the status of this mutual relationship directly influences the level of coordination (Lee et al, 1997). According to Lewis & Talalayevsky, the innovations regarding the information technology affect the way coordination takes place by replacing the human coordination by information related technology and encourage the development of new coordination frameworks. Usually, design decisions concerning the supply chain were completely based on the physical flow of goods, which often did not result in the best choices being made (Lewis & Talalayevsky, 2004). For example, twisted information that makes its way through the entire supply chain can lead to a misleading representation, which results in colossal inefficiencies such as: wrong investments, lost dividend, insufficient client service, inefficient transportation and failing to meet production schedules (Lee et al, 1997). According to Lee et al, the twisting of information could be reduced by shortening the length of the information chain. All in all, it can be stated that the intra-organisational structure may be more likely to be controlled by the flow of information than by the physical flow, as is more common (Huber, 1984). How to improve the information flows within intrafirm supply chains of construction companies is unclear and therefore more research will need to take place (Lewis & Talalayevsky, 2004, Okiria et al, 2017).

1.2.2 Hollandia Infra's perspective

The information flow between the different layers of the company is of high importance. As stated in section 1.1 a distinction can be made between formal and informal information flows. To control an organisation of this size the formal information holds a very dominant and strong position when it comes to information flows. Nevertheless, the instrument of formal information does not always deliver the managers of the organisation the right information to establish proper coordination and strategy. The scarcity of information may lead to irritation and the ones responsible to coordinate may take measures to get their hands on the right information (Macdonald, 1992), which is a problem that Hollandia experiences at times. Conjoining the process of acquiring information informally and the formal information systems of organisations has not been successful so far (Saltsman, 2011). The study of Macdonald indicates that strategies and the way of coordinating an organisation should be based on both the formal and informal information, but chances are that the formal information instruments dominate the informal information, making it more complicated for managers to come up with the correct strategy and coordination (Macdonald, 1992).

Given the above, Hollandia Infra has attempted to increase the role of the informal information flow. In 2015 a program was established called *Hollandia Infra Leadership School (HILS).* This program focuses on the development of social skills and leadership styles that involve personal behaviour, personal knowledge and the use of personal skills. The idea behind this trajectory is that good end results would be the result of a well-developed informal social interaction. Whether or not this program has succeeded is not clear. Hollandia Infra believes that there is room for improvement on how to cope with its information flows. This is mainly due to the belief that making the informal information flow a bigger shareholder in the process of acquiring information will help managers to improve coordinating Hollandia Infra.

1.2.3 Goal of this study

The aim of this study is to explore how information flows can be enhanced within construction companies. This will be done by researching how the information flow can be improved within construction companies making use of a case study concerning the organisation of Hollandia Infra.

1.3 RESEARCH QUESTIONS

The result of this research will clarify how to influence the information flow in a construction company to enhance the coordination. Next to detailed findings, a few reflections on how to improve the information flow in order to enhance the coordination will be provided that might be useful when managing an organisation.

The research question has been formulated according to the objective stated in section 1.2.3 and reads as follows:

'How can information flows be enhanced
in construction projects within a construction company?'

Sub-questions
To be able to answer the main research question, sub-questions have to be answered. The sub-questions are:

1. *'What role does literature accord to information flows in construction projects within a construction company?'*
2. *'What is the intended information flow?'*
3. *'What is the actual information flow?'*
4. *'What is the difference between the intended and actual information flow?'*
5. *'What are important causes that may explain the differences between the intended and actual information flow?'*

The combination of the answers to these sub-questions will form the overall answer to the research question.

1.4 Research Design

This section explains the methods that are needed in order to answer all the sub-questions. Each sub-question is stated followed by the method(s) needed including an explanation on why this method fits this research. At the end of this section an overview of the research structure is provided.

Methods
To answer the given sub-questions, various methods are applied. Each method used per sub-question is shortly elaborated on below.

Sub-question 1: 'What role does literature accord to information flows in construction projects within a construction company?'

Literature study
Literature related to information flows in construction projects will be collected and summarised. The goal is to understand what information flows are and what role they fulfil. Since the question focuses on the role of information flows within a construction company and not between different companies, it is also examined what intrafirm supply chains are.

Sub-question 2: 'What is the intended information flow of Hollandia Infra?'

Company document study
For an organisation to function it is important to have standard procedures so that everyone knows his or her task. This intended information flow is the way the organisation is supposed to work and is referred to as the *workflow* of an organisation. This workflow therefore concerns the procedures an organisation uses to achieve their goals. The workflow of an organisation helps visualising the work that is being done (Trappey et al, 2009).

The way in which Hollandia theoretically organised its information flow, will be studied by the means of a *company document study.* This method is the best suited approach given the fact that during a desk research the data that is collected already exists (Font & Tapper, 2004). It will help creating a visualisation of how the different departments are intended to be working together and who is in contact with whom. This workflow will be substantiated by studying the primary process of Hollandia Infra, which describes what departments are responsible for certain tasks and with whom they are in contact.

Sub-question 3: 'What is the actual information flow of Hollandia Infra?'

Social Network Analysis
A social network analysis is a research method that helps to expose the social structures within, for instance, an organisation (Otte & Rousseau, 2002). Trying to understand the social structures, a social network analysis focusses mainly on the actors present in the social network and the relationships between these actors given a certain social context (Serrat, 2017). According to Serrat, social networks can be defined as '*nodes of individuals, groups, organisations and related systems that tie in one or more types of interdependencies*' (Serrat, 2017, p. 11).

A social network analysis tries to portray the relationships between individuals as completely as possible. It maps formal and informal information flows, can help understand how certain information flows are facilitated or hindered, shows who is in contact with whom (Serrat, 2017). Normally the

results of a social network analysis are shown in a sociagram that helps to understand the social network. The main goal of social network analysis comes down to mapping the social network. In line with this, Cross et al (2010) designed a way in which the state of the relationship can be made transparent as well. In other words this method does not only show who is in contact with whom, but also shows the status of that particular relationship. Cross et al (2010) does this by using four main elements:

- Frequency;
- Responsiveness;
- Effectiveness;
- Energy.

These factors help understanding the nature of the relationship between two individuals and whether or not open communication is present. The information needed to perform a social network analysis, can be obtained by email and for instance social media. However, in most cases it is common that the information is collected manually by using questionnaires and interviews (Serrat, 2017).

To understand how the actual information flow of Hollandia Infra works, a social network analysis will be conducted. A quantitative analysis will be carried out concerning the results of the social network analysis. This quantitative analysis will focus on centrality measures that will help to understand the importance and position of actors in the overall network. Next to this, the social network analysis will help structure which individuals are present in the social structure and how they are connected.

Sub-question 4: 'What is the difference between the intended and actual information flow?'

Constructive comparison
The results from the company document study and the social network analysis will be quantitatively compared in order to find any differences between the intended and actual information flow of Hollandia Infra. The differences that are found indicate that the actual flow of information is different from how it was intended.

Sub-question 5: 'What are important causes that may explain the differences between the intended and actual information flow?'

Semi-structured interviews
In order to find important causes that may explain the differences found in sub-question 4, the participants involved in the demonstrated differences will be interviewed. These interviews will be semi-structured which means that more open-ended questions are included, allowing for a discussion between the interviewer and the interviewee instead of straightforward questions and answers (Kallio et al, 2016). The input gained from these interviews will help explaining why the noted differences occur and help understanding how to enhance the information flows as their opinions are included in the interviews. This will lead to managerial implications that will help enhancing the information flow.

Expert meeting
One more research method will be applied in this study, which concerns expert meetings. The managerial implications will be validated by interviewing two experts. The interviews with the experts will help determine which managerial implications are most important. Both experts will have the ability and the right knowledge to make a well-considered judgment about the work delivered.

Research structure

The methods used in this research are structured throughout this report. This structure is visualised in figure 1.1 in order to provide a clear overview of the research framework.

Chapter	Content		*Method*
1	Introduction		
2	Role of information flows	*SQ1*	*Literature study*
3	Intended information flow	*SQ2*	*Company document study*
4	Actual information flow	*SQ3*	*Social network analysis*
5	Comparison intended vs actual	*SQ4*	*Structural comparison*
6	Causes for differences	*SQ5*	*Interviews and expert validation*
7	Discussion		
8	Conclusions and recommendations	*RQ*	

Figure 1.1: Research framework
Source: Own illustration

1.5 SCIENTIFIC RELEVANCE

Past studies concerning information flows, have shown that lowering the number of actors within an information flow reduces the level of misconceptions and that sharing order-related information influences the mistakes made with predicting demand signals positively (Lee et al, 2000). Other studies suggest that sharing strategic information holds a hidden value that positively influences the production strategies and other marketing aspects of an organisation, which is much broader than just the order-related information (Klein & Rai, 2009). The study conducted by Richard Klein and Arun Rai argues that sharing strategic information in both ways between the supplier and the buyer increases performance for both sides within interfirm relationships. However, this study did not focus on the effects of the information flows within organisations. These effects have to be studied since past research failed to include various informants from the same organisation (Van Bruggen et al, 2002). Future research should therefore focus on including multiple informants from one organisation to shed light on the effects information flows have on the coordination (Klein & Rai, 2009). As suggested by Lewis & Talalayevsky, the way information flows are dealt with have a direct effect on the coordination within an organisation (Lewis & Talalayevsky, 2004). Since the effects the information flow has within organisations is relatively sparsely described in the literature, more studies on the context of management practices should be carried out (Maurice & Sorge, 2000, Barmeyer, 2019).

The literature concerning supply chain management has not covered the intrafirm supply chain to a sufficient level, since intrafirm supply chains experience different complexities concerning the information flows (Farndale et al, 2010). Farndale (2010), therefore suggests that further research should be carried out to explore this area. Practitioners criticize the process regarding the sharing of information in intrafirm supply chains (Mäkiamattila et al, 2014), which solely leans on the interpretation given to it by the project manager (Carleton, 2010).

2 ROLE OF INFORMATION FLOWS

Search terms: Supply chain management, coordination, information flows, team composition, team performance, knowledge diversity & task interdependence

This chapter addresses the available literature concerning information flows within organisations. Section 2.1 covers an introduction on the matter that will provide insight on which topics will be discussed in this literature review. Section 2.2 defines what information flows actually are and how they are viewed in today's literature. Section 2.3 helps to understand what intrafirm supply chains actually are and how it is related to information flows. The last section clearly elaborates on the elements affecting informal information flows.

2.1 INTRODUCTION

Good coordination is very important for an organization to achieve the best possible end result (Malone & Crowston, 1994). Coordination as a concept could be defined as making separate things working together (Tsai, 2002, p. 180). In other words, coordination is a concept that helps the management creating an organisation in which the separate departments work together to achieve one common goal (Mom et al, 2009). The lack of coordination may result in different departments getting out of synch with each other, which creates disarray (Malone & Crowston, 1994). It can therefore be stated that good coordination is of critical importance to organisations and should therefore be invested in (Mom et al, 2009). Good coordination is closely linked to information flows, since these flows provide the management with information which can help making coordinated decisions (Tsai, 2002).

An organisation can be defined as a social system consisting of individuals that all gather information that can be used collectively to achieve a certain goal (Gupta & Govindarajan, 2000, p. 475; Lim et al, 2017, p. 146). To control organisations, different organisational structures have been developed over the years (Mintzberg, 1983). The different organisational structures that are commonly used may often be hard to control and are dependent on several organisational assets (Anumba et al, 2002), in which information flows play an important and strategic role and should therefore be managed (Barmeyer et al, 2019). Information can be transferred from person to person, but to be able to use the information for a higher collective goal the persons, or employees, need to be willing to share their information (Cameron & Webster, 2011). To control these information flows a goal-oriented approach is required. Over time, different mechanisms have been developed in order to control and structure information. For instance, an organisation can pursue a policy in which employees have to share their information and knowledge in databases that are available for every colleague (Maier, 2009). However, one should not forget that passing on knowledge and experience is a form of implicit information, which is dependent on the experience of the narrator and can therefore not always be properly documented (Frappaolo, 2007). Another disadvantage of such a system is that *trust* forms the basis for the willingness to actually share knowledge, and given the fact that most of these platforms are anonymous, trust is a lacking issue (Costigan et al, 1998). A study into the use of these information managing systems to save and spread information through the organisation shows that these are used much less often than was initially thought (Rowe & Te'eni, 2014). In contrast to these formal information managing systems, there are also informal forms that organisations use to share information (Whelan, 2016). According to Whelan, these informal forms heavily rely on mutual relationships between employees (Whelan, 2016). In southern European countries establishing personal relationships is vital for getting the right information (Barmeyer et al, 2019). The findings of

the study conducted by Christoph Barmeyer, show that the coffee break plays a crucial role in Italian organisations and is directly linked to information circulation (Barmeyer et al, 2019). In other words, in southern European countries, the informal information flow plays a huge part in obtaining and spreading information within organisations.

2.2 INTRAFIRM INFORMATION FLOWS

2.2.1 Information flows

A lot of past studies focused on the effectiveness of organisations (Alexander & Gaston, 2001). It is a common understanding that effective communication is essential for the functioning of organisations (Fielding, 2006). The field of work dedicated to enhancing the level of effectiveness concerning communication is called 'information management'. This type of management concerns the process to assemble and provide information within organisations (Barmeyer et al, 2019). However, assembling all the information available within organisations is easier said than done, as certain information is tied to the information holder who also decides whether or not the information will be part of the overall circulation of information (Wiig, 2016). According to Wiigg, whether or not an organisation will become successful comes down to individual choices and individual actions of the employers who all fulfil a certain role within the organisation (Wiig, 2016). In other words, the success of an organisation is determined by, among other things, the individual actions that lead to the sharing of information.

2.2.2 Explicit and implicit information flows

Traditionally, the sharing of information has been split into two main categories, namely implicit and explicit information (Goyal et al, 2014). It can be imagined that an individual has more information than he can actually share. The category of implicit information concerns the skills of an individual, which can sometimes be hard to describe since it can concern personal information and therefore cannot be easily merged into the circulation of information (Frappaolo, 2007). Next to implicit information, there is explicit information. This form of communication leaves nothing to the imagination and is therefore much more tangible and thus can be easily merged with the formal information system (Ellis, 2004). Nevertheless, successfully transmitting information between individuals highly depends on the willingness of the information holder to actually share the information (Barmeyer et al, 2019).

In organisations, information flows can also be divided into formal and informal information flows (Macdonald, 1992). The formal information flow concerns information that is more practical and is independent of individual information holders, for instance construction drawings or specifications (Barmeyer et al, 2019). In contrast to the formal information flow, the informal information flow heavily relies on individual information holders and their willingness to share information (Liu & Milanova, 2010). In practice it is very common and accepted that the formal information flow is supported by informal input, such as comments, suggestions or explanations (Soda & Zaheer, 2012).

In practice, the focus within organisations is mainly on the transfer of formal information, because this can be offered through IT systems in a fairly simple way and can also be re-used (Barmeyer et al, 2019). The fact that it can be re-used is the main reason for organisations to prefer this way of recording information since it can be seen as an investment in the future (Peansupap & Walker, 2006). To make a thorough choice on which IT system to use, organisations must invest in communication technology and should educate their employees on how to record the needed information in the chosen IT system (Rowe & Te'eni, 2014). This does not mean, however, that these IT systems are suitable for any form

of information as it is limited to formal and explicit information (Johannessen et al, 2001). According to Johannessen et al, this limitation of IT systems can lead to the result that tacit information, which is hard to digitalise, will play a background role, while this form of information is of strategical added value to organisations such as sustainable competitive advantage (Johannessen et al, 2001). This problem can be countered, but the solution requires organisations to invest in creating social networking between experts (Martin & Bavel, 2013). These social networks will result in contact moments between employees, which benefits the information circulation. Informal information is mainly shared between individuals who already maintain a personal relationship (Willem & Buelens, 2007). However, it is important that informal information between individuals that do not maintain a personal relationship is shared as well. Applying social networks create spontaneous communication which will accomplish an informal information circulation (Oddou et al, 2009). The value of these informal information circulations cannot be expressed in the same way formal systems can, for example in the amount of calculations or documents, but rather in exchanging individual experiences and knowledge (Polanyi, 1966).

A study conducted by Johannessen, Olaisen and Olsen suggests IT information systems fail to function as mechanisms that create sustainable competitive advantages when formal information flows predominate informal information flows, and thus result in mismanagement of knowledge (Johannessen et al, 2001). To tackle this problem, organisations have to invest in developing knowledge strategies that are fixated on organisational learning, innovation and continuous improvement processes (Johannessen, 2001).

The current literature concerning information flows and information technology disregards and underestimates spontaneous informal information circulation (Maier, 2009). Given its critical effect on the sustainable competitive advantageous, organisations should manage the informal information flow as serious as the formal information systems. A suitable start to invest in the development of the informal information flow, would be to create moments and places where individuals are able to share information in an informal way, such as halls or lunch breaks (Leistner, 2012). Social moments during work time are also used for coordination of workflow and coming up with solutions to current problems (Barmeyer, 2019).

2.3 INTRAFIRM SUPPLY CHAINS

The first sub-question focusses on the role information flows have in construction projects within construction companies. As this study specifically focusses on intrafirm information flows, intrafirm supply chains have to be explained as well.

2.3.1 Supply chain management

The literature defines supply chain management as the integration of the most important processes of an organisation from the beginning until the finishing of the product, in which information plays a critical role creating the final product effectively (Moharana et al, 2012). A supply chain concerns all the different departments, layers of an organisation or sometimes different companies that add value to creating a certain product (Fugate et al, 2006). According to Fugate et al, managing such a supply chain effectively requires a synergetic relationship between each of the individual supply chain members, but that an effective control mechanism to coordinate these chains is often missing (Fugate et al, 2006). The lack of an effective control mechanism that a manager can use to establish proper coordination within an organisation will often result in individual members of the supply chains trying to optimize their specific field of interest without taking into account the effect on the total system performance (Moharana et al, 2012).

The development in the area concerning information technology has been fierce the last decade and has enabled organisations to increase the level of communication and thus creating a tighter coordination (Fugate et al, 2006). The coordination mechanisms, which are means to solve certain coordination related problems, are at the heart of the supply chain management (Tsai, 2002). In other words, the information flows within organisations helps establishing a tighter coordination which helps to make the best possible coordinated decisions (Tsai, 2002). It could be stated that coordination is used to optimize the achievements of organisations within the supply chain network in which the right information is perhaps the most critical element (Moharana et al, 2012). The findings of a study conducted by Shin state that the development and use of information technology establishes a higher level of coordination and can also help to enhance the coordination by lowering the costs spend on this very subject (Shin, 1999). According to Shin, the improvements made on coordination result in a higher firm productivity and organisation performance (Shin, 1999).

2.3.2 Coordination

Organisations are an aggregation of activities that often depend on one another (Malone & Crowston, 1994). To control organisations, a management is appointed. Coordination is one of the responsibilities of the appointed management of which its primary goal is to ensure that the different departments and various composed groups are all in line with each other, which requires a form of unity (Kogut & Zander, 1996). This form of management also establishes a harmonious ambiance when achieving the goals set by the organisation (Mom et al, 2009). According to Mom et al (2009), coordination is a critical aspect for all organisations since more than one individual is included to pursue one common goal. Therefore it can be stated that coordination comes down to a process of synchronizing different attempts from various departments of the organisation in order to reduce conflict-related problems (Tsai, 2002). The lack of coordination may result in different departments getting out of synch with each other, which creates disarray (Malone & Crowston, 1994).

2.3.3 Explicit versus implicit team coordination

The principle of coordination can be split into explicit coordination and implicit coordination (Chang, 2017). Explicit coordination needs time to be established and leans on the input of accepted means (Eccles & Tenenbaum, 2004). According to Eccles & Tenenbaum, planning, objective formation, creating relations and a clear divisions of roles will contribute in creating an efficient explicit coordination (Eccles & Tenenbaum, 2004). Past literature has mainly focused on this explicit side of coordination. In contrast with the explicit team coordination, implicit team coordination involves interaction between colleagues in order to acquire substantive knowledge that helps to complete their task and improves implicit coordination (Levesque et al, 2001). This form of coordination relies mainly on the ability of employees to predict actions of other colleagues to prevent mistakes (Tee, 2015). Therefore, implicit coordination mechanisms can be defined as mechanisms that enable individuals to anticipate to actions of colleagues and heavily rely on the status of the mutual relationship (Espinosa et al, 2002).

It can be concluded that managing information flows, especially the informal information flows, will help establishing implicit coordination (Espinosa et al, 2002). Coordinating an organization can only go well if there is a well-developed information flow, the value of which should not be underestimated (Barmeyer, 2019).

2.3.4 Informal information flows influencing coordination

The two main components that are located at the heart of implicit coordination are the ability of individuals to anticipate to actions of their fellow colleagues and the ability to adjust to dynamic circumstances (Levesque et al, 2001). Influencing the informal information flow will have an effect on the implicit coordination and thereby effect the overall coordination of an organisation. Former research, conducted by Rico et al, developed team situation models and moderated the impact of implicit coordination on team performance by examining the role of several characteristics of work teams divided in three major categories (Rico et al, 2008). Key characteristics that influence the implicit coordination, according to Rico et al, are (e.g. Rico et al, 2008; Anand et al, 2003; Wong, 2003; Okhuysen & Bechky, 2009; Fisher et al, 2012):

- Team composition;
  - Longevity;
  - Knowledge diversity;
- Team-specialised aspects;
  - Trust;
  - Group effectiveness;
- Work environment;
  - Task routineness;
  - Task interdependence;
  - Virtuality;

Each of these elements, and how it exerts influence is explained in detail below. The elements form a framework of team implicit coordination processes, as can be seen in figure 2.1.

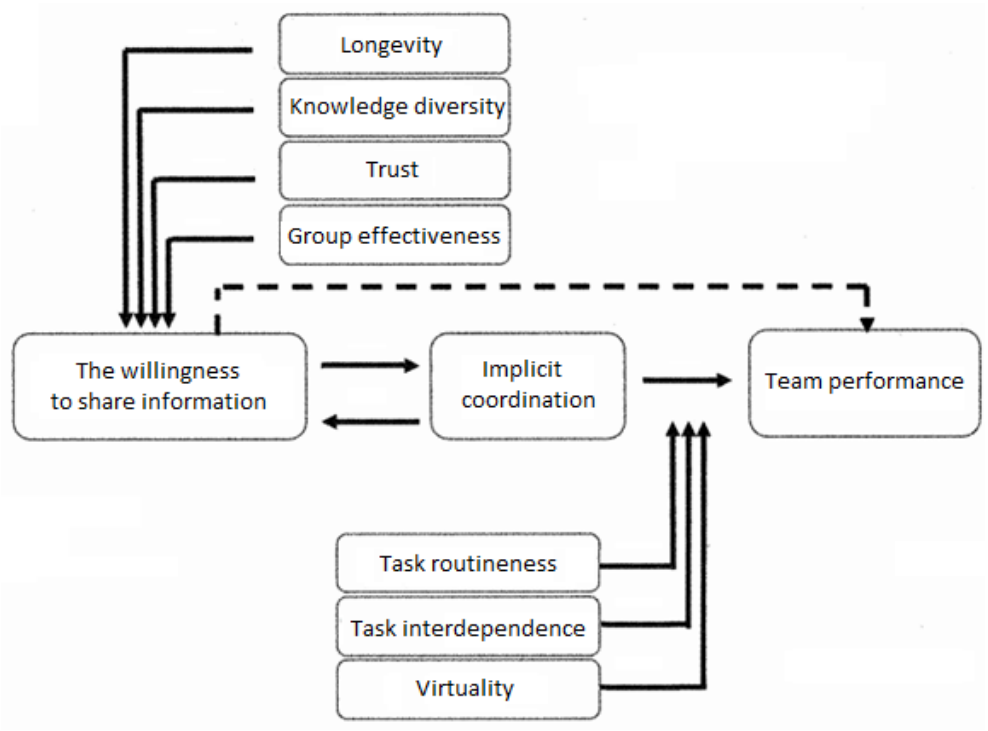

Figure 2.1: Framework for Team Implicit Coordination Processes
Source: (adjusted from Rico et al, 2008).

Team composition

Team composition has become increasingly important for organisations in order to influence team effectiveness (Bell et al, 2010). Composing a team with individuals with specific characteristics will influence the results booked by the team (Bell et al, 2015). Looking at team situation models that establish implicit coordination, the effects of the life span and knowledge diversification on the informal information flow are most important (Rico et al, 2008; Bell et al, 2010).

Longevity

The time the same individuals work together and function as a team influences the existence of team knowledge, since the social relationships get the chance to grow and the individuals get the opportunity to learn from one another (Langan-Fox et al, 2004). Next to this, people are more willing to provide and receive criticism from colleagues, which will improve the overall team performance and contributes to establishing a mutual social network (Wang et al, 2017), and thereby influencing the informal information flow positively. Individuals that worked only for a short period with one another tend to be more formal and this therefore negatively affect the informal information flow (Rico et al, 2008).

Knowledge diversity

This characteristic is about the circulation of relevant knowledge to achieve the goals set by the organisation (Lauring & Selmer, 2013). The experiences and knowledge gained over the years by individuals differs per individual (Rico et al, 2008). Sharing their knowledge and experiences with the rest of the team will not only increase the overall knowledge of the team, but will also increase the willingness of individuals to retrieve information in a comparable way as it is understood that everyone has different knowledge that may be valuable (Rentsch & Zelno, 2003).

Team-specific aspects

Team-specific aspects are aspects that can only be attributed to a team consisting of individuals with specific qualities (Choi et al, 2020). According to Choi et al, these aspects influence, for example, intra-team communication and the level of knowledge exchange (Choi et al, 2020). The two most important aspects with a direct link to implicit coordination are trust and group effectiveness (Rico et al, 2008).

Trust

Trust is a critical team-specific aspect that affects the knowledge acquisition and if there is a lack of trust it may affect the willingness of a group member to be vulnerable towards other group members (Maurer, 2010; Scott-Young et al, 2019). This means that trust is of critical importance for an individual to take risks, adapt to new situation and the level of acceptance concerning being dependent on one another (Imam & Zaheer, 2021). When team members experience trust within a team by feeling that sharing information is safe, the overall informal information flow is stimulated and thus, the level of implicit coordination (Bond-Barnard et al, 2018).

Group effectiveness

The effectiveness of a group can be defined as the communal confidence to commence given tasks and successfully complete them (Gibson & Earley, 2007). According to Gibson and Earley, this aspect influences what activities team members want to undertake to give colour to their role and how far they are willing to go to complete tasks (Gibson & Earley, 2007). These activities could be, for example, exchanging information and experiences, shaping strategies and taking feedback from colleagues, which enhances the implicit coordination of organisations (Rico et al, 2008).

Work environment

A feature that is critical for the performance of an organisation is the work environment in which tasks are being performed (Goetz et al, 2021). This contributes to the creation of an implicit coordination, in which especially task routine, task interdependence and virtuality play a major role (Rico et al, 2008).

Task routineness

Task routines can be divided into two groups, namely highly routine tasks, in which situations are more predictable and problems can be solved following a well-known standardized path, and non-routine tasks, in which situations are less predictable and problems require more unique acts and more input of information to be tackled (Rico et al, 2008). A higher level of highly routine tasks has a negative effect on the implicit coordination level, since individuals need less input from others (Howerd-Grenville et al, 2016). More non-routine tasks will lead to a higher level of implicit coordination given the fact that more input from others is needed to successfully complete tasks (Beghetto, 2017).

Task interdependence

The task interdependence represents the degree to which different tasks are interconnected (Saavedra et al, 1993). The more tasks are dependent on one another, the more the task performer is stimulated to seek contact with others (Bertucci et al, 2016), and thus share information and positively influences the informal information flow. Tasks that are less dependent on one another can more easily be handled by one individual (Bertucci et al, 2016), and thus negatively influence the informal information flow.

Virtuality

Virtuality, in the given context, is the degree to which individuals within organisations rely on virtual tools to get the information needed to execute their tasks (Kirkman & Mathieu, 2005). This means that a high level of virtuality means that people highly rely on the formal information flows within their companies (Rico et al, 2008). In contrast, a low level of virtuality means the informal information flow is more crucial in requiring the needed information (Rico et al, 2008).

2.4 CONCLUSION

The first sub-question of this research concerns the role of information flows in construction projects within construction companies according to the literature. The answer to this first sub-question is provided in this chapter.

Information flows are the route the information travels between different departments or individuals. Information flows can be divided into formal and informal information flows. Formal information flows are less dependent on individual information holders and function according the agreed means, like for instance construction drawings. Informal information flows are far more dependent on individual knowledge and ones willingness to share this information. The literature states that the formal information flows have dominated the informal information flows over the last decades. This is obvious given that the focus of organisations is mainly on the transfer of formal information as an organisation provides and produces generic information and guidelines. Yet the literature claims that the individual information holder may be of much greater importance than originally thought.

The literature states that the total flow of information influences the coordination, but that this is difficult to map because it is unclear how the informal information flows function exactly. Former studies have shown that influencing the informal information flows will have an effect on the implicit coordination of organisations. The most important characteristic, based on the literature, is *the willingness to share,* which directly affects the successfulness of transmitting information between team members. Another important characteristic is the *task interdependence* between team members.

3 INTENDED INFORMATION FLOW

This chapter aims to describe the intended information flow of Hollandia Infra, based on a company document study. The goal is to create insight in the way Hollandia Infra is organised and how the different departments and layers are connected to each other. This chapter will also show the critical departments of the company, which will function as input for the social network analysis which is described in the next chapter.

3.1 THE PRIMARY PROCESS MODELLING PROCEDURE

There are several ways in which workflows can be modelled. These different ways focus on slightly different aspects, for instant task orders, time management, automating processes or creating a simulation of reality (Janssens et al, 2000). Therefore, it must be stated clearly what the scope of the model will be, what different procedures of the primary process will be part of the model and how the workflow information is gathered (Dehnert & Van der Aalst, 2004). The steps needed to model the workflow of Hollandia Infra are shown in figure 3.1. This also outlines how this chapter is structured.

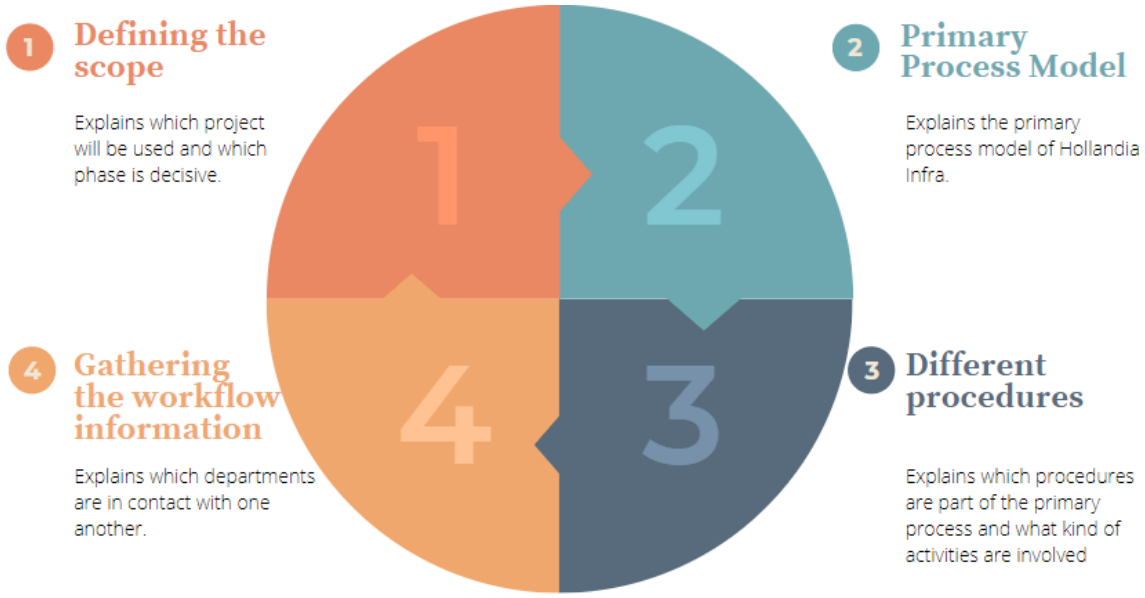

Figure 3.1: Steps to model the primary process of Hollandia Infra.
Source: Adjusted from (Dehnert & Van der Aalst, 2004).

3.2 DEFINING THE SCOPE

Every organisation has several procedures that together form a certain way of working. This is called the workflow as it is originally intended by an organisation (Janssens et al, 2000). Hollandia Infra also uses various processes that together form the workflow. Since Hollandia is a large company with many complex procedures running side by side, one benchmark project is chosen to model the primary process. This benchmark project concerns Tilbury in England producing 6 lock gates. This project is an average project for Hollandia infra and that is why the primary process is normative.

Hollandia is responsible for the design and construction phase of the project. Both phases deal with information flows, but the construction phase is more dynamic given the fact that more different assets of the organisation are needed to complete this phase. Since the aim of the research is to

enhance the information flow, the construction phase seems more interesting than the design phase. Therefore the construction phase of the Tilbury project will be used to model the primary process.

Project description

Great Britain has had problems with severe flooding in the past decade. These floods have caused major nuisance to local residents and also caused major damage. To tackle this problem, a ten-year trajectory has been set up to replace and strengthen the flood defences in London and the mouth of the River Thames. An important first step in this is the development of an environmental plan that clearly describes how the flood risk of the mouth of the River Thames can be managed until 2100.

The current tidal barrier is no longer sufficient and needs replacement as The Port of Tilbury is the last protection between the waters of the Thames and thousands of homes. The existing lock gates will be replaced by pioneering dual-function lock gates that will manage the flood risk of the area. Next to this, it will provide a new navigation system for operations in the harbour (Hollandia, 2021).

Hollandia Infra has been approached by the Environment Agency of England to develop six new lock gates for the Port of Tilbury. These six new lock gates will be steel pointed doors and will be placed in three sets of two doors. The two outer doors will also be having a retaining function. For this reason, these two gates are equipped with barriers to stop the water of the Thames in case of high water. This lowers the chance of flooding.

These six lock gates are completely produced in the construction shed of Hollandia Infra, see figure 3.2. When the production of these lock gates is finished they will be transported by ships to Tilbury Harbour where they will be installed. The old lock gates are removed, disassembled for the re-use of parts. At the end of 2021 the first two doors will be transported by Hollandia Infra to England. On site, the old lock gates are lifted out and the new lock gates will be installed. All six doors will be installed by the end of May 2022 after which the project is handed back to the Environment Agency.

Figure 3.2: Construction of lock gates being produced at the Hollandia Infra production hall.
Source: Hollandia Infra, 2021

Workflow aspects

Next to the scope, it is important to determine which elements form the total workflow. The literature on workflow models has been widely distributed and knows various methods to model the workflow. Before a workflow can be modelled the number and different kind of entity types that provide most information need to be acknowledged. Although there is a lot of different literature available on this topic, that regularly apply different methods, the next five essential entity-types seem to match: (Muehlen & Rosemann, 1998; Eggersman et al, 2002; Marquardt & Nagl, 2004)

- The steps and actions needed in the primary process and what they depend on;
- The information resulting from the actions undertaken that is required for the implementation of the primary process;
- The roles that are fulfilled within the organization by the actors;
- The necessary resources needed to execute activities;
- The material needed to execute activities.

Next to these five essential entity-types, the literature also mentions other aspects like time, knowledge holders and flexibility. In this research the workflow is used to acquire the network relations as is intended by the organisation. Therefore it is clear that not all entity-types are relevant. The relevant entity-types that are used in this research are: the actions undertaken by the actors, the information flow and the actors consulted and whom they inform. The necessary resources and materials are not part of this research.

3.3 Primary Process Model

The structure of the organisation of Hollandia Infra is visualised by the use of an organisational chart, see figure 3.3. Using this organisational chart, Hollandia Infra tries to establish the best possible mutual communication with a view to increased productivity. Hollandia's approach is that proper information flows between the different departments will lead to successful execution of the projects.

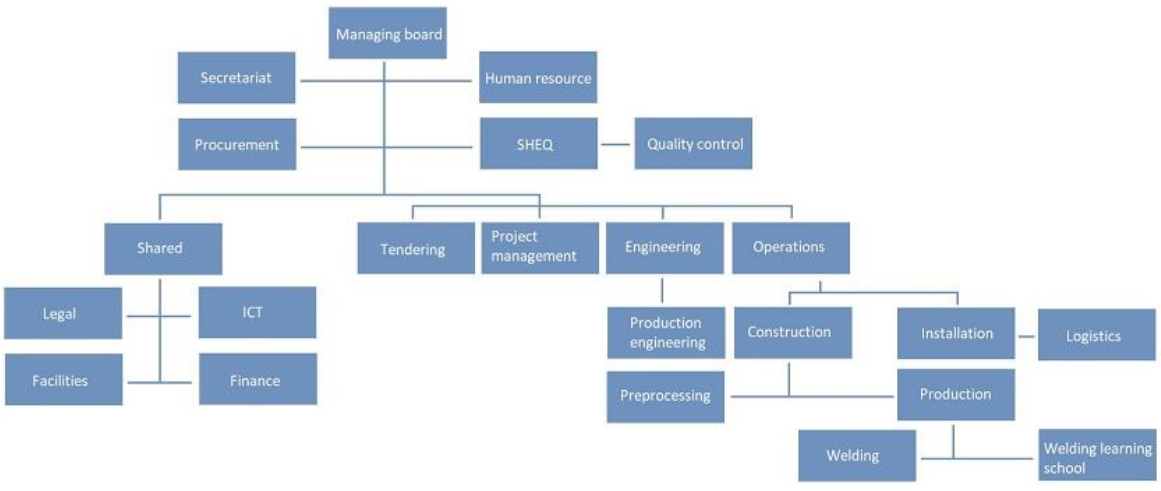

Figure 3.3. Organisational chart Hollandia Infra B.V.
Source: Hollandia Management System

The aspects named construction and installation are all covered under the discipline *operations*. This technically means that there are four major disciplines that actually carry out the projects, namely tendering, project management, engineering and operations. The tender department is responsible for bringing in the projects. This essentially means that they compete with other companies in order to win the tender and thus the projects. The project management is responsible for ensuring that the project runs smoothly. They form the link between the wishes of the client and the interests of Hollandia Infra. The project engineers work closely with the project managers and also try to translate the client's wishes into technical requirements that represent the interests of Hollandia. Operations is responsible for the actual construction, production and installation of the project. This includes the actual building of bridges, lock gates and other steel structures.

The working method within Hollandia infra can be distinguished in two different types of processes: the primary process and the supporting processes. The primary process of Hollandia Infra, given the benchmark project of the Tilbury Gates, consists of the next stages:

- Tendering;
- Project management;
- Engineering;
- Production;
- Installation;

The construction phase of the primary process mainly consists of the production and installation aspects. It goes without saying that contact points will also exist between the engineering that made the design and the actual construction. Therefore the main focus will be on the engineering, production and installation.

Supporting processes of Hollandia Infra that play a role in the aforementioned three parts of the primary process are:

- Quality control;
- Production engineering;
- Logistics.

These supporting processes only support the primary process, but are of vital importance when looking at the contact moments between the different actors. In consultation with Hollandia Infra it was decided that the three above mentioned supporting processes will also be a part of this thesis.

3.4 Different Procedures

This section describes the process steps relevant to the construction phase and shows how these steps are executed. In these processes, a dichotomy has been created between the primary processes and the supporting processes. Both are explained in this chapter. The explanation for the abbreviations used for the functions of the actors can be found in appendix A.

3.4.1 Primary processes

The primary process steps that are relevant for the construction phase consist of the next processes: engineering, production and installation. Each process is elaborated below and is visualised as a workflow model in figure 3.4. at the end of this chapter.

Engineering

The engineering process concerns activities in which customer requirements, applicable standards and internal (project) requirements are met. The idea is to design the construction, which in this case concerns six lock gates. The engineering process consists of four different steps that overlap and thus form a trajectory.

The *first* step concerns the *designing* of the construction. The goal of this step is to ensure that the designs made meet the requirements of the customer, legislation and regulations and internal (project) conditions. During this step, the design engineer (DE) is primarily responsible for the execution. The project engineer (PE), fabrication manager (MFAB) and the design and engineering manager (DEM) are often consulted by the DE and the director (DIR) should be kept informed.

The *second* step concerns the detailed calculations. This step ensures that plans made meet the requirements of the customer, legislation and regulations and internal (project) conditions, and that the data necessary for implementation is available by drawing up detailed calculations. The PE is primarily accountable and needs to be in close contact with the PM, DEM. These contact moments go both ways as it includes consults as well as informing.

The *third* step is a quantity determination to ensure that it is clear how much and which material must be present for the production of a design, so that it can be ensured that sufficient material is available on time. During this step the PE is accountable and maintains close contact with the draught design engineer (DRDE), DEM and DIR.

The *fourth* and final step concerns the delivery of the workshop drawings. The goal of this step is to ensure that workshop drawings and the products manufactured on the basis thereof meet the requirements of the customer, legislation and regulations and internal (project) conditions. The DEM and MFAB are accountable for the execution of this step. They need to consult the draught engineer (DRE) and the customer. Next to this, the PE and the PM must be informed during this step on the progress of this step.

Production

The production process concerns the realisation of all manufacturing activities within the applicable project specifications. The goal of this process is to produce the ordered product, in this case the six lock gates. In order to execute this process successfully, Hollandia Infra created 3 main steps.

The *first* step concerns the preparation in which the goal is to control the pre-processing of materials according to specification including selection, marketing and tracing of materials. The general foreman (FOG) is accountable for this first step and is responsible to consult with and inform the PE and the quality controller (QCE).

The *second* step has the function to control the dimensions. This step ensures the correct dimensions of parts and meeting the internal or external wishes regarding measurement protocols, in order to meet the specifications. The construction manager (CM) and the PE are responsible for this step and

are supposed to consult with the PM, MFAB and the quality checker (QCI). They also have to inform the foreman (FO) on the latest updates.
The *Third* and final step concerns the machining operations. This step ensures the correct execution of machine operations, in order to meet the specifications and requirements. The PE and FO are primarily accountable and are responsible to maintain close contact with the MFAB, construction manager (CM) and the FO.

Installation
The installation process concerns the assembling of the product on the specific location, in this case the port of Tilbury. This process only has one specific action which is realizing the assembly of the fabricated elements within time and budget in a qualitatively good manner, taking all necessary safety measures into account. The performer (UITV) and the site manager (SM) are accountable for this step and are responsible to consult with the PM and keep the PM and PE informed during this process step.

3.4.2 Supporting processes
The supporting processes that are relevant for the construction phase of projects consist of the next processes: quality control, production engineering and coordinating conservation. Each process is elaborated on below based on process information acquired from Hollandia Infra.

Quality control
The goal of this process comes down to coordination, recording and execution of quality control activities within the set project requirements. Quality control work concerns requirements and quality checks during the engineering phase, construction work in the field, control of manufacture, conservation and installation. The most important roles in this process are the assembly manager (ASM), the quality engineer (QCE), the quality checker (QCI) and the manager of SHE and quality (MSHE). The quality engineer, the quality checker and the manager of SHE and quality are responsible for the entire process. In order to execute this process successfully the project team , project engineer and the project manager are often consulted. Next to this the contact with the assembly manager is maintained and is therefore kept closely informed.

Production engineering
The goal of this department is realising timely and high-quality production and information in order to fabricate parts taking into account the materials, resources and software systems present in the company. This department is responsible for preparing the implementation so that it runs as smoothly as possible. The most important role in this process is the work planner (PL) and the production engineer (PN) who are responsible for the entire process. During this process the planner will often consult with the project engineer and the quality controller. The planner will also inform the project team and the fabrication manager about the progress of the process.

Logistics
This procedure describes the method for coordinating the conservation of parts including transport, monitoring progress and additional work, but excluding any associated purchase/technical purchase. The most important role in this process is the logistic foreman (LGF). During this process, the LGF mainly consults with the logistic manager (LGM), the project team (PT) and the fabrication manager (FABM).

3.4.3 Workflow model

In order to create a clear understanding of the workflow of the primary process and the important supporting processes, the primary process steps that maintain a direct relation to the construction phase of the project and the necessary steps that need to be executed are visualised in figure 3.4, including the important supporting processes.

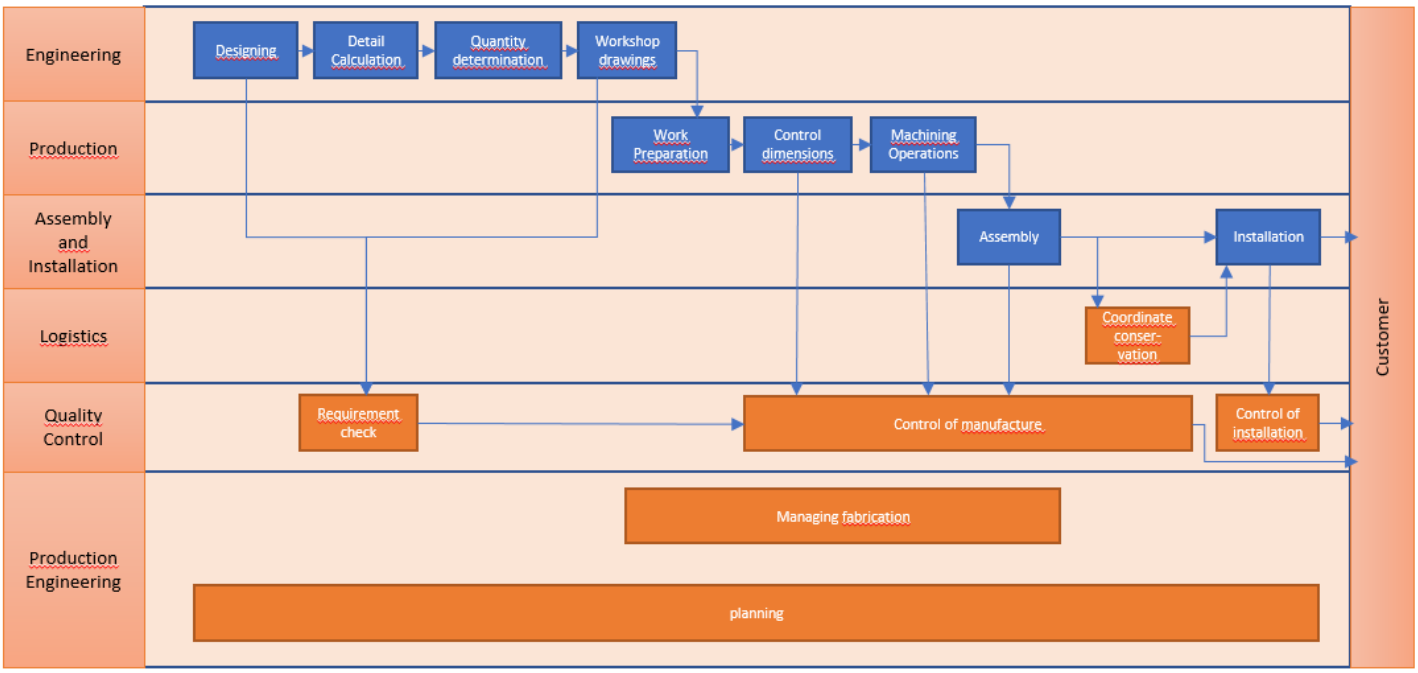

Figure 3.4. Workflow model of the construction phase of Hollandia Infra.
Source: Adjusted from the documentation on Primary processes and supporting processes of Hollandia Infra.

3.5 GATHERING THE WORKFLOW INFORMATION

3.5.1 The intended contacts between actors

The workflow model based on the primary process and a few supporting processes has been elaborated on in the previous section. It is now clear what disciplines are important in this primary process and, based on this workflow model, it can be assumed who is in contact with whom according to the organisational structures of Hollandia Infra. These contact moments are summed up in table 3.1 and uses scores 0 or 1 to indicate whether or not contact is present. Only half of the matrix is filled in as it mirrors its content.

The results of table 3.1 have been checked by an expert on the organisation structure of Hollandia Infra. This expert is a board member and has been working at Hollandia for fifteen years. The interview with the expert can be found in appendix H1.

Table 3.1. Existence of intended contact moments between disciplines (appendix A contains the explanation of the abbreviations)
Explanation matrix: Value 0: No contact moments present; Value 1: Contact moments present

	PM	PE	CM	MFAB	FOG	FO	ILE	HIN	SUP	QCE	QCI	PL	PN	LGF	LGM	ASM	DE	DEM	DIR	DRDE	DRE	MSHEQ
PM		1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	0	0	1	0	0	0
PE			1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	1
CM				1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	0	0	1
MFAB					1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
FOG						1	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1
FO							0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	1
ILE								1	1	0	0	0	1	0	0	0	0	0	0	0	0	1
HIN									1	1	0	0	1	0	1	0	0	0	0	0	0	1
SUP										0	0	0	0	1	1	0	0	0	0	0	0	0
QCE											1	0	1	0	0	1	0	0	0	0	0	1
QCI												0	1	0	0	1	0	0	0	0	0	1
PL													1	0	0	0	0	0	0	0	0	0
PN														0	0	0	1	1	1	1	1	0
LGF															1	0	0	0	0	0	0	1
LGM																0	0	0	0	0	0	1
ASM																	0	0	0	0	0	1
DE																		1	1	0	0	1
DEM																			1	0	0	1
DIR																				0	0	1
DRDE																					1	1
DRE																						1
MSHEQ																						

3.5.2 Quantitative analysis

The previous section visualised the intended information flow. The intended information flow shows who is in contact with whom. In line with this, this section will provide the quantitative analysis that helps to understand the influence one individual is intended to have on the entire network. To achieve this analysis, the next four parameters are important (Ergün & Usluel, 2016):

- Degree centrality;
- Betweenness centrality;
- Closeness centrality;
- Eigenvector centrality.

The parameters are all calculated with the input from intended information flow on who is in contact with whom, using the program NodeXL, see appendix C1.

Degree centrality

The degree centrality is a measure that provides insight in the importance of a node/actor. This is done by checking how many connections this node/actor has in comparison to other nodes/actors. This parameter helps to find very well connected individuals and less connected individuals. This is an interesting parameter since it shows which individuals are more likely to hold most information.

Betweenness centrality

It sometimes happens that information does not go directly from one actor to another, but that several actors are involved in between. The betweenness centrality is a measure that shows how many times a certain node/actor is part of the shortest path between other actors to pass on information. This shows which actors function as a bridge between other actors.

Closeness centrality

This measure is closely related to the 'betweenness centrality' measure. The closeness centrality calculates all the shortest paths between all the different actors. In this way every actor gets a score that shows how often he/she is in the shortest paths. This measure therefore shows which actors are often present in the shortest paths and thus of crucial importance to the entire network. These important actors have a direct influence on the entire network.

Eigenvector centrality

The eigenvector centrality and the degree centrality are closely related. Just like the degree centrality, the eigenvector centrality measures how many connections an actor has. However this specific measure also takes into account how many connections these connections have. By doing this, the eigenvector centrality identifies actors that not only influence the actors to which it is directly linked to but also which actor influences the entire network.

The software *NodeXL* is able to calculate the parameters mentioned above. The results of these calculations can be found in appendix C1. A four-quadrant visualization of the above mentioned parameters is applied, see figure 3.5. The X-axis represents the degree centrality and the Y-axis represents the betweenness centrality. The two orange coloured lines, presenting the average value of the x-axis and the y-axis, divide the graph into four quadrants. The size of the node represents the closeness centrality. The meaning of the four quadrants is explained in table 3.2.

Table 3.2: Four-quadrant explanation – Centrality		
Quadrants	*Degree centrality*	*Betweenness centrality*
Quadrant 1 (Q1)	Low	High
Quadrant 2 (Q2)	High	High
Quadrant 3 (Q3)	Low	Low
Quadrant 4 (Q4)	High	Low

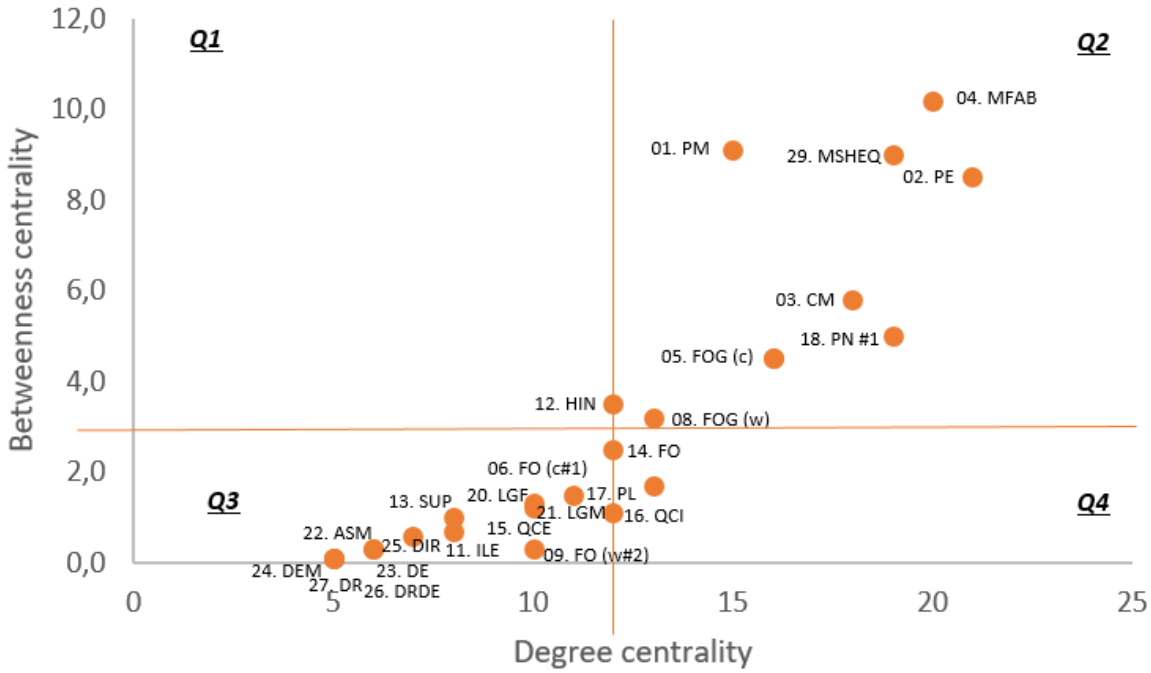

Figure 3.5: Four-quadrant centrality – Intended centrality positions
Source: Own illustration using centrality scores calculated with NodeXL

Almost all actors seem to be located in the second and third quadrant. The centrality calculation clearly shows which actors have the most central role as these are placed in the second quadrant. These roles concern respectively the manager of fabrication, the manager of SHE & Quality, the project manager, the project engineer, the construction manager, the production engineer and the general foremen.

The individuals in quadrant 3 have a rather low degree of centrality and a low betweenness centrality. This means these people are not necessarily influencers of the intended network. Quadrant 4 has a high degree centrality which means they mostly engage in direct contact. The lower betweenness centrality means they do not often form a bridge between other actors.

3.6 CONCLUSION

The purpose of this chapter was to understand the intended information flow, as is the goal of the second sub-question. This has been attempted by carrying out a company document study from which a workflow model emerges. At the beginning of this chapter the procedure to substantiate the workflow model for the construction phase was explained. The first step concerned the defining of the scope which showed that the relevant entity-types are: the actions undertaken by the actors, the information flow and the actors consulted and whom they inform. The next natural step concerned the understanding of the organisational structures that together form Hollandia Infra's organisation. It turned out that the engineering, production and installation departments constitute the primary process for the construction phase. A few supporting processes are vital in the overall primary process, which is why they are included as well.

The insight into the workflow and what the function of the different actors is, has led to the disclosure of the mutual relationships and the associated information flow. These contact moments are shown using a matrix consisting of the two values 0 and 1. This clearly shows which actors are intended to have contact with one another, based on the workflow. Using the software NodeXL the intended centrality scores of the actors have been calculated. This shows how central each role is intended to be within the intended network. The centrality calculation clearly shows which actors are intended to have the most central role as these are placed in the second quadrant. These roles concern respectively the manager of fabrication, the manager of SHE & Quality, the project manager, the project engineer, the construction manager, the production engineer and the general foremen.

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4 ACTUAL INFORMATION FLOW

This chapter concerns the social network survey that forms the basis of the entire social network analysis. The goal is to gain insight in the links between actors and the quality of the relationships. There is not just one method to make a social network transparent. It is therefore important to determine how the social network should be displayed prior to designing the social network. This chapter shows how the social network should be displayed and what social network survey will provide the right information. Following up on this, the results of the Social Network Survey will be analysed, ultimately leading to a visualisation of the actual information flow for the specific case.

4.1 A SUITABLE METHOD

In past studies several methods have been used to perform a social network analysis. Since there is a specific reason for performing a social network analysis (Kocchakzadeh et al, 2011). In this specific research two reasons for executing a social network analysis can be distinguished. The first one is to find out whether there is a difference between the intended formal information flow and the actual information flow. This difference is based on whether or not expected and/or unforeseen contact is present. The second one is to find out what the status of the relationships is. This part will help determining what Hollandia Infra can improve in their implicit coordination. The method chosen in this research includes both these aspects.

Wang (2016) investigated the workflow between participants in the FEED phase in a thesis for the TU Delft. In order to do this, Wang (2016) used a binary snowball method approach. This method is specially designed to identify a network, but does not include how the network functions. In other words, it will show the differences between the workflow and how this actually functions according to the social network analysis, but leaves the function of the relationship untouched. Eggermont (2017) tried to capture the status of the relationship by using a valued approach, instead of the snowball approach, and comparing the results with a RECAP analysis (Suprapto, 2016) in order to improve the collaboration between the general contractor and the subcontractor.

The social network analysis will take place during the construction phase. The everyone in the entire network is included in the construction phase. The snowball method therefore does not seem to be the proper method for this research. Next to this, the aim of this research is to find out how the information flows can be improved in order to enhance the coordination of Hollandia Infra. It is therefore very important that the elements affecting the implicit coordination, as explained in section 2.4, will be part of the social network survey. However, in order to improve the information flows it is of vital importance to understand what kind of contact takes place and not just whether contact takes place or not. When applying a valued approach, it is possible to provide insight into the quality of the relationship by using a score of 0 to 5. This method therefore provides insight in whether or not contact between certain participants is taking place or not, and it shows the quality of the relationship.

In this research the value based approach is used in performing the social network analysis. Cross et al (2010), created four different dimensions (frequency, responsiveness, effectiveness and energy) to capture the nature of a relation within an organisation (Cross et al, 2010). Certain elements of Rico et al (2008), such as the willingness to share and task interdependence, are closely linked to the dimensions used by Cross et al (2010). This makes the SNA questionnaire as developed by Cross et al (2010) very suitable for this research. Therefore the network survey of Cross et al (2010) will be supplemented by these elements.

4.2 MEASUREMENT

There are various known methods on how a questionnaire can be translated to a measurement (Koochakzadeh et al, 2011). The value measurement approach is more fitting. This approach shows whether a contact is present, but also shows the state of the relationship by applying a score of 0-5. The study of Cross et al, 2010, gives meaning to the value of the score, see table 4.1. The questions asked in this method and the meaning of each score can be found in appendix B.

Table 4.1: Score meanings Social Network Analysis Source: Cross et al, 2010

Score	Interpretation
0	Unknown
1	Lowest
2	Low
3	Neutral
4	High
5	Highest

A score of 0 implies that no contact between the actors is present. When a score of 1-5 is given by a participant this implies that contact is present. In a binary system any score between 1 and 5 equals 1. This way the results of the social network analysis can be compared to the intended workflow of Hollandia Infra as is presented in table 3.1. in section 3.5. However, this score also provides insight into the status of the relationship. The implicit coordination is dependent on the mutual relationships of the people working in the organisation. Adding the two factors of willingness to share and task interdependence to the questionnaire, as designed by Cross et al (2010), creates the possibility to conclude on the status of the implicit coordination within Hollandia Infra.

4.3 PARTICIPANTS

This research focusses on the construction phase of the project. During the construction phase, the departments, that are part of the primary process of Hollandia Infra, called engineering, construction and installation are in contact with one another. In order to really be able to clarify how the information flows through the organisation in the construction phase, all three of these departments must be represented in the social network analysis. Most participants are from the construction department, given the fact that this department is the most important during the construction phase. In total 21 participants participated in this social network analysis. The distribution of these 21 participants and their corresponding functions is given in table 4.2.

Looking at table 4.2, it can be concluded that not all roles identified in chapter 3 are found. This is because not all roles from the formal process are actually fulfilled in this specific case. The role of manager SHE & quality is also not reflected in Table 4.2. This is because this is an open vacancy at the time this research was conducted. The roles that are shown in table 4.2 provide a realistic view of the project team for this specific case which was checked with Hollandia Infra.

Table 4.2. Social Network Analysis - Participants

Function	Number of participants
Engineering Department	
Project Manager	1
Project Engineer	1
Construction department	
Construction Manager	1
Manager Fabrication	1
General Foreman (construction bank)	1
Foreman (construction bank)	2
General Foreman (welding)	1
Foreman (welding)	2
Installation	
Installation Leader	1
Head Installation	1
Supervisor	1
Foreman (installation)	1
Quality Control	
Quality Engineer	1
Quality Checker	1
Production engineer	
Planner	1
Production engineer	2
Coordinating Conservation	
Logistic foreman	1
Logistic manager	1

4.4 SURVEY

The survey the participants have to fill in consists of six different elements that need to be given a score of 0-5. The first four elements concern frequency, responsiveness, effectiveness and energy. These elements and the associated questionnaire have been developed by Cross et al (2010) and have not been adjusted. The last two elements concern the 'willingness to share' and 'task interdependence'. These two relationship related elements influence the implicit coordination present in the organisation and have been added to the questionnaire.

The list of the participants and the total survey including its questionnaire can be found in appendix B.

4.5 COLLECTING THE INPUT

In section 4.3 the 21 individuals that participated in the Social Network Analysis have been identified. All 21 participants function within one of the key primary or supporting processes that have been determined in section 3.4. Given the fact that this study is carried out during the corona pandemic, in which many people work from home and being present in the office is not always possible, the survey was not conducted verbally but was sent via e-mail. It took well over three weeks for all participants to fill in the survey, including a few reminders. The final result is that all requested participants have finally completed the survey, therefore the response rate is 100%.

The analysis of the SNA results consists of three parts. The first part concerns a visualisation of the network, see section 4.6. This shows who is in contact with whom using the frequency scores. Following up on this, a quantitative analysis has been conducted in order to gain insight in the centrality scores of the actors, see section 4.7. This shows how central the role of each actor is in the total network.

The third part analyses the status of the relationship, see section 4.8. This includes the remaining three elements responsiveness, effectiveness and energy. This part of the analysis will also elaborate on the two added factors willingness to share and task interdependence. All these elements are analysed by looking at the scores of the survey and visualising the results in order to draw any conclusions.

4.6 VISUALISATION ACTUAL INFORMATION FLOW

The names of the participants have been replaced by their role in combination with a number. The numbering corresponds to the previously used numbering as in section 3.5.

The result of the Social Network Analysis, concerning the presence of contact, between all the different roles that play a key part in the primary process and additional supporting processes in the project of Tilbury can be seen in figure 4.1. This figure shows that actors from all different departments concerning the primary process and additional supporting processes are connected with one another. The actors, or roles, are presented as nodes (the black dots), and the presence of contact with other actors is represented by the grey lines, which are called edges.

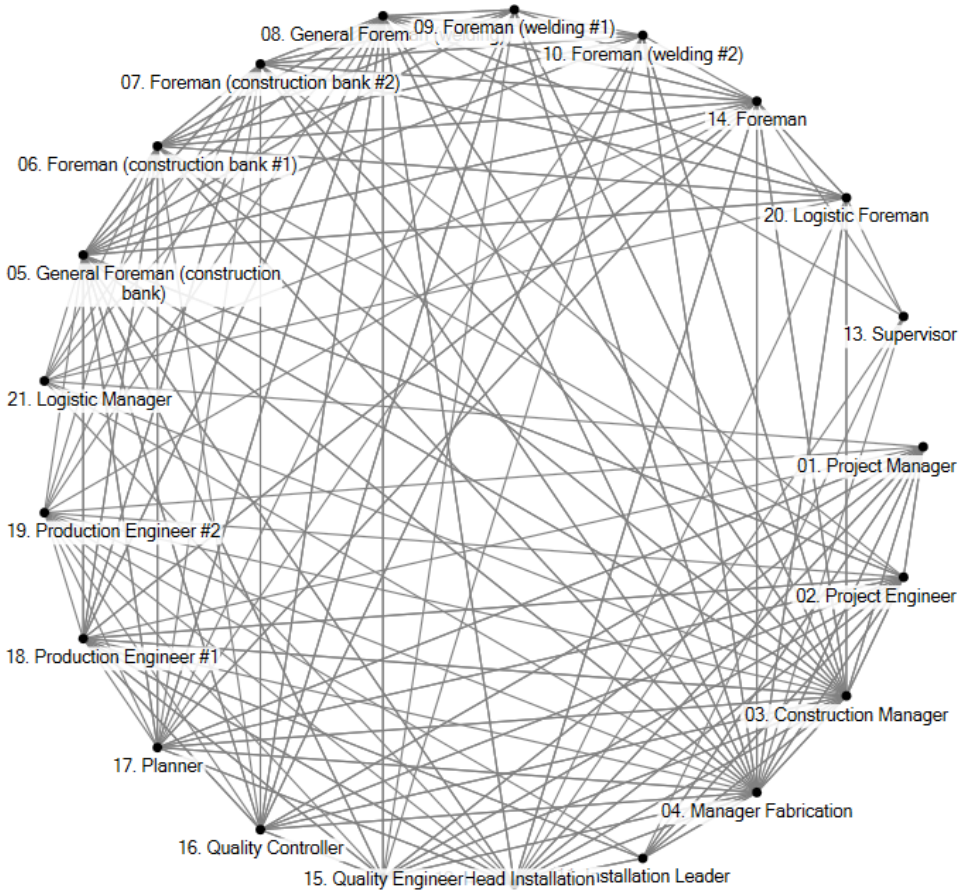

Figure 4.1: Result of SNA survey on the presence of contacts.
Source: Own illustration using NodeXL

The vertices in figure 4.1. are undirected since contact moments work in both directions. The observation that there is contact between two parties is what is important and thus the direction of that contact is left out. Counting the edges present in figure 4.1. shows that the total number of edges comes down to 216, see table 4.3.

Table 4.3: SNA graph information	
Graph layout	Circle
Graph type	Undirected
Unique edges	70
Total edges	216
Amount of vertices	21
Maximum Geodesic Distance	2
Average Geodesic Distance	1,26
Graph Density	0,68

The Geodesic Distance is a number that represents how many contact points are present between two people. In the most favourable scenario, this number is only 1 because these two people are in direct contact with each other and no intermediary is required for the transfer of information. However, sometimes people are not in direct contact with one another. In this case the maximum number of edges between actors comes down to 2. The Average Geodesic Distance is 1,26 which can be interpreted that all actors are well connected since actors averagely do not need to consult other actors in order to get to information. The graph density is the percentage of edges present divided by the maximum number of possible edges. In this case this comes down to 68%, which means that 68% of all possible edges is actually present.

Table 4.4 has been created to better understand the visualisation of figure 4.1. This provides an overview of the current information flows. The numbers in this table are the results of the scores given for the element 'frequency' which indicates how often contact moments takes place. Table 4.4 thus shows who is in contact with whom and how often this contact occurs.

Table 4.4. Existence of actual contact moments between disciplines (appendix A contains the explanation of the abbreviations)
Explanation matrix: - Value 0: No contact moments present; Value 1-5: Contact moments present (appendix B shows the meaning of the 1-5 scores);

	PM	PE	CM	MFAB	FOG (c)	FO (c#1)	FO (c#2)	FOG (w)	FO (w#1)	FO (w#2)	ILE	HIN	SUP	FO	QCE	QCI	PL	PN #1	PN #2	LGF	LGM
PM		5	5	1	0	0	0	0	0	0	3	1	0	0	3	4	1	4	2	0	1
PE			3	2	3	2	2	0	0	0	4	1	0	0	2	3	1	5	5	0	0
CM				3	4	2	1	4	3	3	1	2	0	2	2	2	3	3	3	2	2
MFAB					5	3	3	5	3	3	2	3	1	3	2	2	4	3	2	1	3
FOG (c)						5	5	5	4	4	0	1	0	2	2	2	2	4	4	2	4
FO (c#1)							5	5	5	5	0	0	0	1	0	1	2	4	4	4	2
FO (c#2)								5	5	5	0	0	0	1	0	1	0	4	4	4	2
FOG (w)									5	5	0	1	1	1	2	3	2	2	1	1	3
FO (w#1)										5	0	0	0	1	0	3	0	0	0	0	0
FO (w#2)											0	0	0	1	0	3	0	0	0	0	0
ILE												1	1	0	0	0	0	1	1	0	0
HIN													1	4	2	0	2	2	2	0	3
SUP														2	0	0	0	0	0	1	2
FO															0	0	1	1	1	2	4
QCE																4	0	1	1	0	0
QCI																	0	3	3	0	0
PL																		5	5	0	0
PN #1																			4	0	0
PN #2																				0	0
LGF																					5
LGM																					

4.7 QUANTITATIVE ANALYSIS

The previous section visualised the network actual information flow. In line with this, this section will provide the quantitative analysis that helps to understand the influence one individual has on the entire network. To achieve this analysis, the next four parameters are important (Ergün & Usluel, 2016):

- Degree centrality;
- Betweenness centrality;
- Closeness centrality;
- Eigenvector centrality.

The parameters are all calculated with the input from the Social Network Survey about who is in contact with whom, using the program NodeXL, see appendix C2. This quantitative analysis shows the centrality of the actors in the information flow as suggested by the results of the SNA score 'frequency'. A quantitative analysis has already been performed in section 3.5 concerning the intended information flow. The centrality parameters explained in this section are again applied in this quantitative analysis.

A four-quadrant visualisation of the above mentioned parameters is applied, see figure 4.2. The X-axis represents the degree centrality and the Y-axis represents the betweenness centrality. The two orange coloured lines, presenting the mean value of the x-axis and the y-axis, divide the graph into four quadrants. The size of the node represents the closeness centrality. The meaning of the four quadrants is explained in table 4.5.

Table 4.5: Four quadrant explanation – Centrality

Quadrants	*Degree centrality*	*Betweenness centrality*
Quadrant 1 (Q1)	Low	High
Quadrant 2 (Q2)	High	High
Quadrant 3 (Q3)	Low	Low
Quadrant 4 (Q4)	High	Low

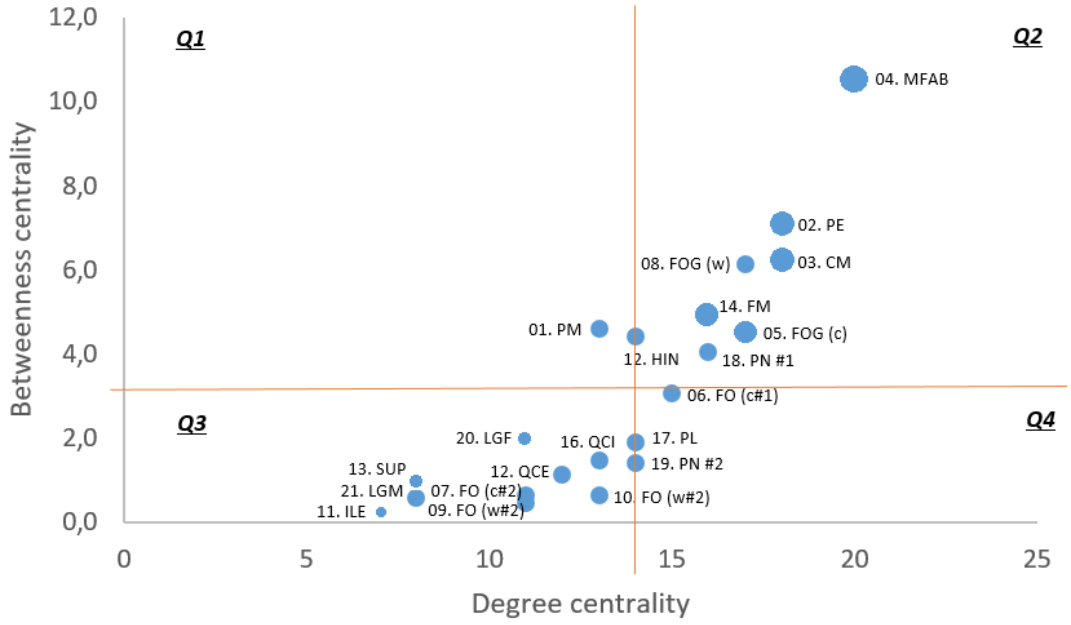

Figure 4.2: Four-quadrant centrality – actual centrality positions
Source: Own illustration using centrality scores calculated with NodeXL

Quarter 1 has almost no actors, as can be expected since a high betweenness centrality means you function as a bridge between actors which is hard when your number of connections (degree centrality) is rather low. However there is one actor in this quadrant which happens to be the project manager. The fact that the betweenness centrality measure of the project manager is rather high seems logical, since the project manager functions as a bridge between actors. The SNA, however, shows that the degree centrality is not particularly high. This is due to the fact that the project manager has no contact with the people on the work floor, such as welders. For this reason the degree centrality of the project manager may seem a bit low and following this the score of the fabrication manager is higher since he does have these contact points.

The individuals in quadrant 3 have a rather low degree of centrality and a low betweenness centrality. This means these people are not necessarily influencers of the network. Quadrant 2 has a rather high degree centrality and betweenness centrality. The highest of all being the manager of fabrications, which is as expected given its central role in the construction phase. The project engineer and construction manager also occupy high positions when looking at influencing the network. Al actors in this quadrant have management related roles, which is to be expected. Quadrant 4 has a high degree centrality which means they mostly engage in direct contact. The lower betweenness centrality means they do not often form a bridge between other actors.

4.8 STATUS OF THE RELATIONSHIP

The previous section translated the 'frequency' scores of the Social Network Analysis into a visualisation of the actual information flow. However, this analysis reveals nothing about the state of the relationship. This section deals with the outcome of the SNA on the various elements as described by Cross et al, 2010 and the two added factors related to implicit coordination. The lower scores on the various elements are more worrying. Many low scores on an element can mean that improvements are needed here. Given the many inputs from the SNA, it was decided to mainly display the lower scores because these may contain interesting improvement opportunities for Hollandia Infra, however all results can be found in appendix D.

4.8.1 Responsiveness & Effectiveness

The first two elements of Cross et al, 2010 to be analysed concern the responsiveness and effectiveness. Both results from the SNA have been visualised in a grid lay-out because this provided the clearest overview. Figure 4.3 shows the slower responsiveness results and figure 4.4 the more ineffective ties. Figure 4.6 shows how often each score occurs, but as explained earlier, the figures show only the lower scores, up to a maximum of score 3, for clarity.

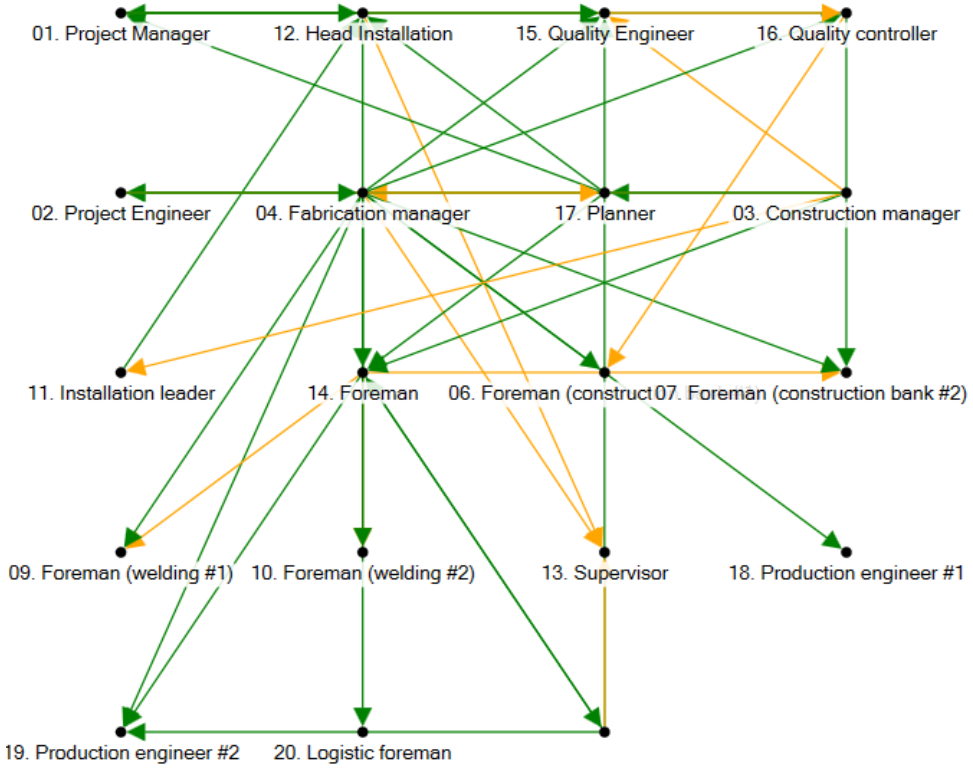

Figure: 4.3: Low responsiveness scores – SNA results – Score 3: green, Score 2: orange, Score 1: red.
Source: Own illustration using NodeXL

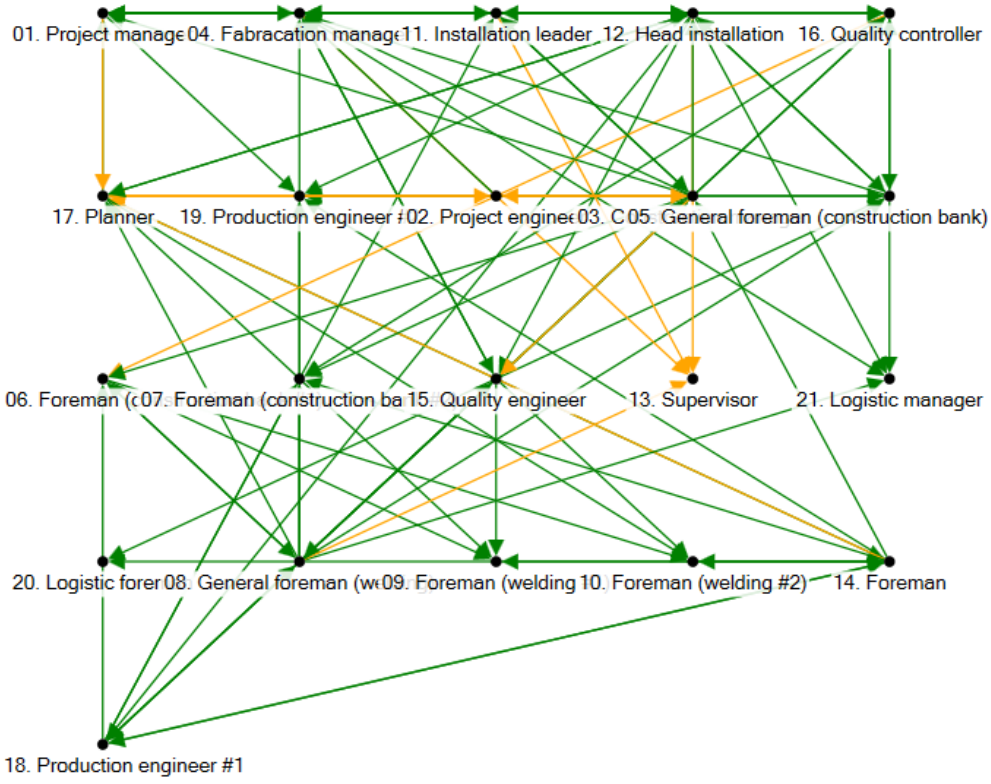

Figure: 4.4: Low effectiveness scores – SNA results – Score 3: green, Score 2: orange, Score 1: red.
Source: Own illustration using NodeXL

Table 4.6: Number of occurrences of each score – Responsiveness & Effectiveness				
Responsiveness			**Effectiveness**	
Scores	*Number of occurrences*		*Scores*	*Number of occurrences*
1	0		1	0
2	12		2	11
3	30		3	101
4	102		4	99
5	72		5	5
Average score	4,1		**Average score**	3,5

The averages as provided in table 4.6 indicate the amount a certain score is given. The outcome of the SNA shows that the average score for responsiveness equals 4,1. To be clear, this indicates that the score of 4.1 is the average score the participants give to each other regarding responsiveness. The average score on effectiveness is a bit lower and equals 3,5.

Responsiveness and effectiveness are irrevocably linked. In practice, someone can react very quickly and thus have a high responsiveness score, but the response in question does not necessarily have to be effective. Therefore, a 4-quadrant overview has been created that plots both values against each other, see figure 4.5. The dots represent the participants of the SNA study. The x-axis presents the responsiveness and the Y-axis the effectiveness. The coordinates of the participants arise from the average scores assigned to the two given elements. The calculation of the scores has been attached in appendix E and are not provided in figure 4.5 in order to keep a clear overview. A brief explanation of the four quadrants is given in Table 4.7.

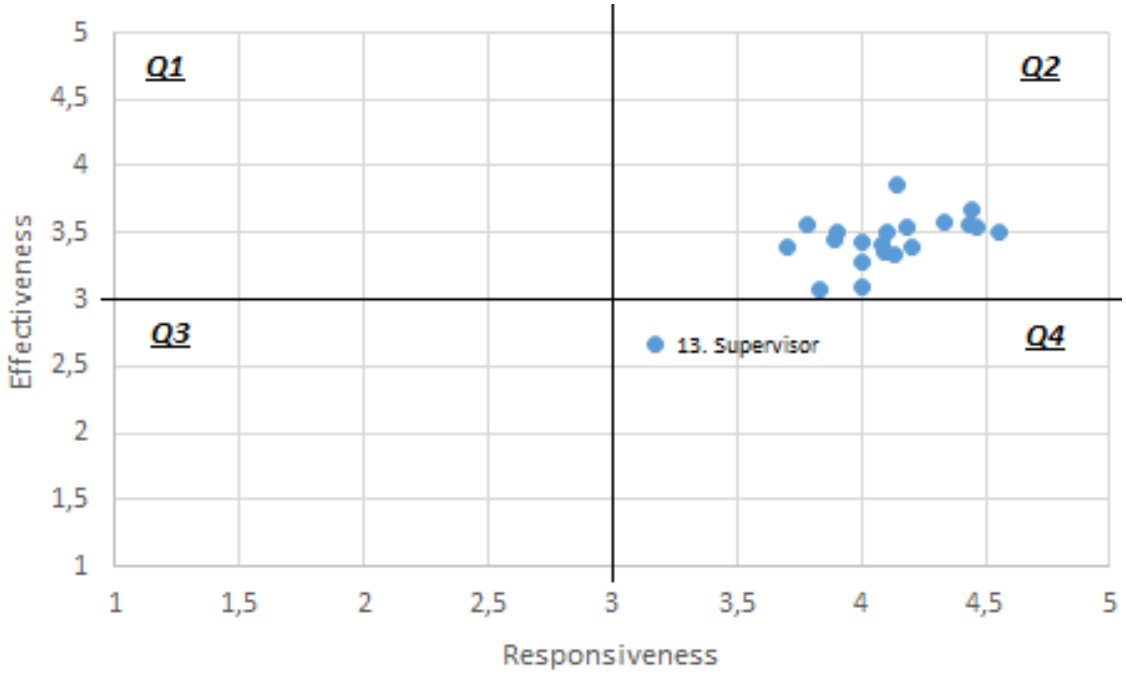

Figure 4.5: 4-quadrant visualisation – Responsiveness x Effectiveness
Source: Own illustration using the scores of the SNA

Table 4.7: Four quadrant explanation – Responsiveness x Effectiveness		
Quadrants	*Responsiveness*	*Effectiveness*
Quadrant 1 (Q1)	Low	High
Quadrant 2 (Q2)	High	High
Quadrant 3 (Q3)	Low	Low
Quadrant 4 (Q4)	High	Low

The average lines that divide the scheme, presented in figure 4.5, into four quadrants are located at the score of 3,0, since this score functions as a neutral score. As table 4.6 already states, the average scores of all participants of the SNA study on both elements are higher than a score of 3. Practically all participants can therefore be found in the second quadrant, which implies that they are both quick to respond and effective. Only one participant does not score in the second quadrant, but just moves to the fourth quadrant. This participant happens to be the supervisor who scores a tad lower on effectiveness. This suggests that the supervisor, compared to the other participants, is found to have the lowest responsiveness scores and effectiveness scores, as is suggested by the participants in the Social Network Survey.

4.8.2 Energy

The fourth and last part of the method of Cross et al, 2010, concerns energy. The results of the scores of this element are presented in figure 4.6.

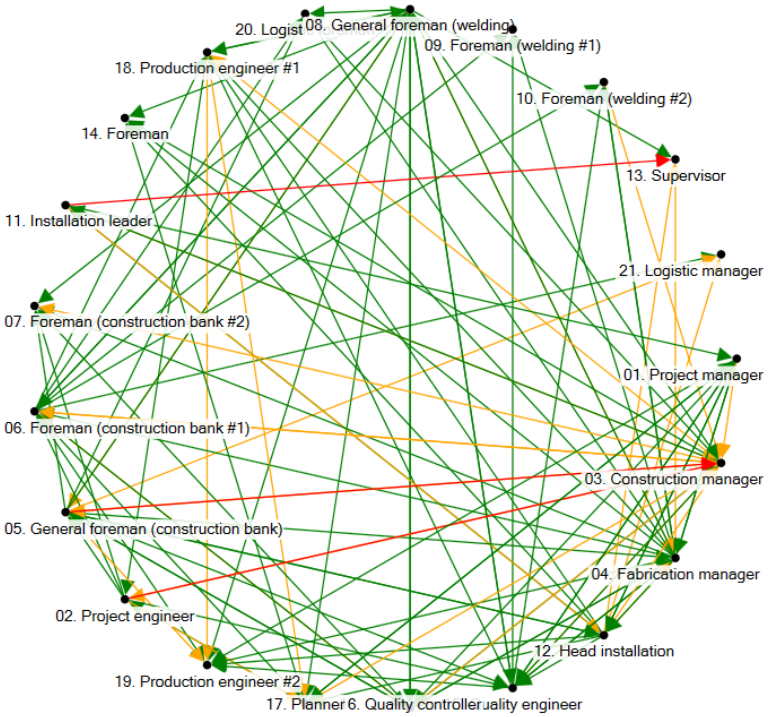

Figure 4.6: Low energy scores - SNA results - Score 3: green, Score 2: orange, Score 1: red.
Source: Own illustration using NodeXL

In this visualization it was also decided to only show the lower scores as these are the most interesting to Hollandia Infra. Only the scores 1, 2 and 3 can be seen, in which 3 again functions as a neutral value since this is neither a low nor a high score. The layout is chosen in the form of a circle and not in a grid

form as in the previous section. This has been done since there are more low scores and a circular layout provides a clearer overview. Table 4.8 shows how often each score occurs, but as explained earlier, the figures show only the lower scores for clarity.

Table 4.8: Number of occurrences energy related scores.	
Energy	
Scores	*Number of occurrences*
1	3
2	25
3	112
4	69
5	7
Average score	3,2

Table 9 shows that the average score given in the SNA study equals 3,2, which implies that in most cases that is no energizing effect, in other words neutral. The score of 3 functions as a neutral value since it is high nor low. The mean score of 3.2 indicates that in most cases the participants have no de-energizing effect on each other, however they also do not have an energizing effect on each other. Still, the result tends to fall more towards the energizing side than the de-energizing side.

4.8.3 Willingness to share & Task interdependence

The two added implicit coordination related factors concern the *Willingness to Share* and *Task Interdependence.* The results of the scores of both factors have been visualised. The willingness to share is visualised in figure 4.7 and the task interdependence is visualised in figure 4.8. In terms of layout, the willingness to share is visualised using a grid form and the task interdependence is visualised using a circle form. In both cases this was chosen because it offers the best overview.

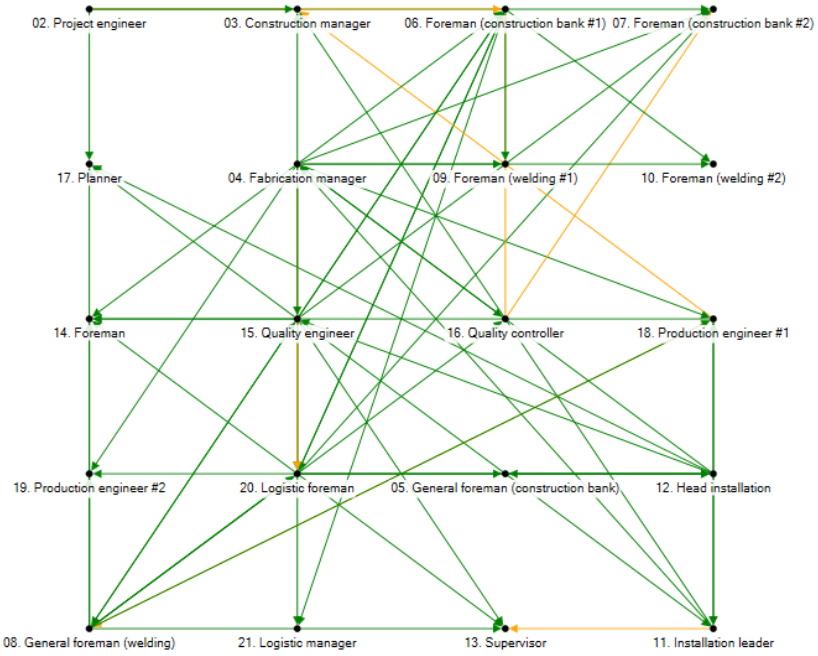

Figure 4.7: Low 'willingness to share' scores – SNA results - Score 3: green, Score 2: orange, Score 1: red.
Source: Own illustration using NodeXL

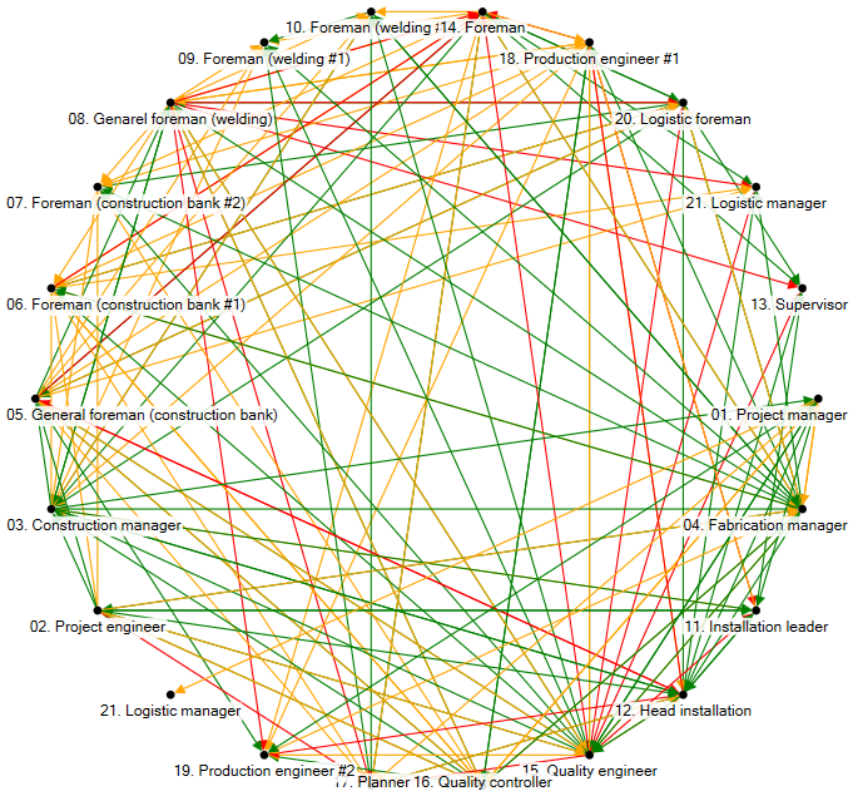

Figure 4.8: Low 'task interdependence' scores – SNA results - Score 3: green, Score 2: orange, Score 1: red.
Source: Own illustration using NodeXL

Table 4.9 shows how often each score occurs, including the higher scores.

Table 4.9: Number of occurrences of each score– Willingness to Share & Task Interdependence

Willingness to Share			**Task Interdependence**	
Scores	*Number of occurrences*		*Scores*	*Number of occurrences*
1	0		1	21
2	6		2	62
3	54		3	68
4	132		4	52
5	24		5	13
Average score	3,8		**Average score**	2,9

To better visualise the results of these two factors, both are plotted in a coordinate system, see figure 4.9 and 4.10. The numbers on the x-as represent the actors with the same number as shown in appendix B. The orange line shows the average score. To be clear, the average score per actor as presented in figure 4.9 indicates the average score that the other participants provide to the actor. This score indicates to what extent the participants claim to be willing to share their information with this specific actor. Figure 4.10 indicates to what extent the participants claim to be dependent on the specific actor.

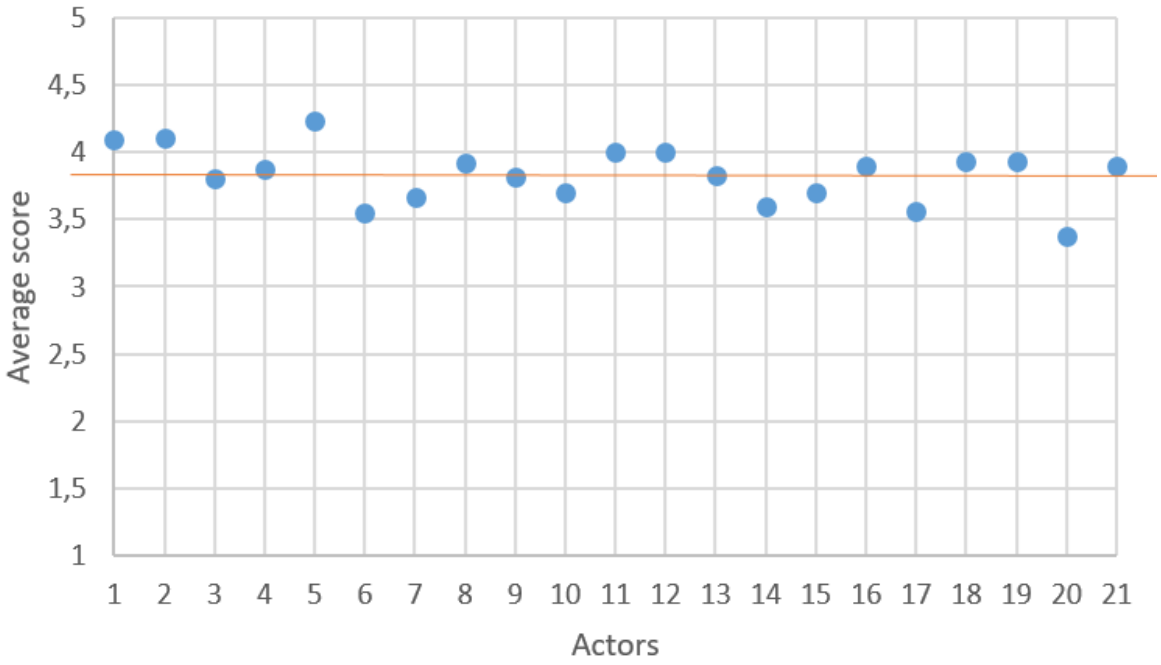

Figure 4.9: Average results per actor – Willingness to Share
Source: Own illustration using the scores of the SNA

The outcome of the SNA shows (table 4.9) that the mean score of *willingness to share* equals 3,8. Looking at the distribution of the scores it can be concluded that the lower score of 2 is rarely present and the lowest score of 1 is completely absent. The mean value of 3,8 almost equals 4, which indicates that most participants are pro-actively sharing information.

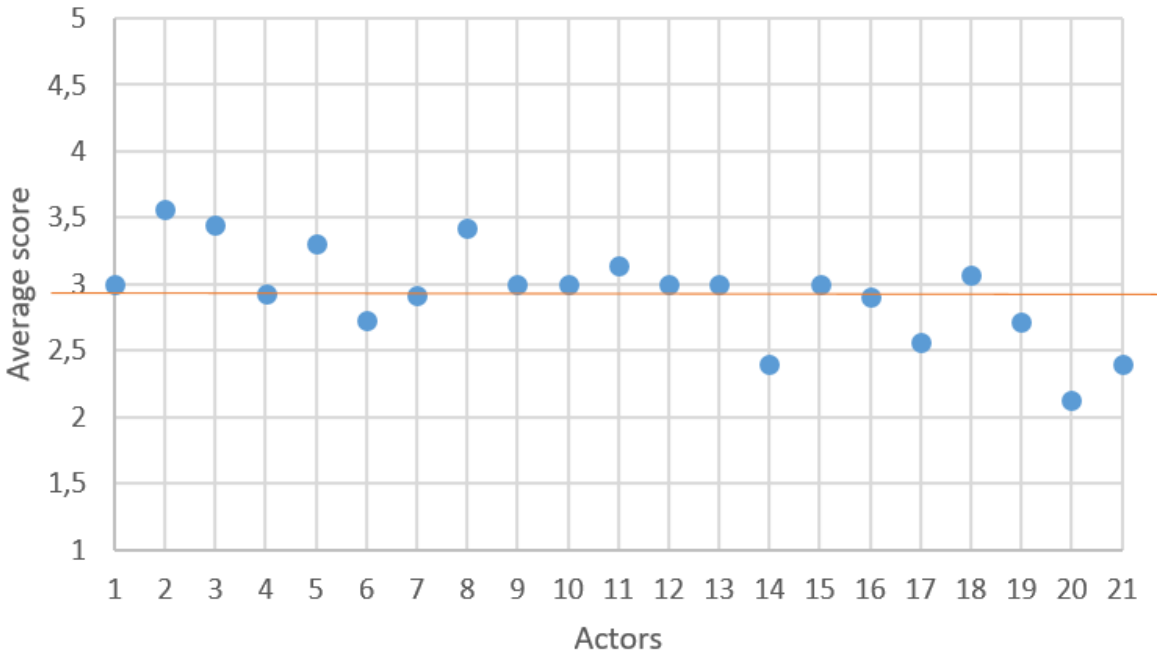

Figure 4.10: Average results per actor – Task Interdependence
Source: Own illustration using the scores of the SNA

The average score for task interdependence is a bit lower and equals 2,9. This mean score indicates that most participants are moderately dependent on one another. Figure 4.10 shows that scores for task interdependence are a bit more scattered. The average score of 2,9 almost equals the neutral

score of 3. This implies that the average individual in this network is not necessarily independent of most of his colleagues, but neither is this average individual dependent.

4.9 Conclusion

The scores on the element 'frequency' have directly contributed to the creation of a visualisation of the actual information flow. This was the main goal of this chapter as it helps answering the third sub-question. Studying the results of the SNA by means of centrality measures it can be concluded that the manager of fabrication has the most central and influential position during the construction phase of the project. Next to the fabrication manager, the project engineer and the construction manager are the most central roles in the actual network.

The SNA results provide insight in the status of the relationships. The results responsiveness and effectiveness show average scores of 4,1 and 3,5, which implies that all members of the network consider one another to be both quick to respond and effective. The results on the element energy show that in most cases the participants have no de-energizing effect on each other, however they also do not have an energizing effect on each other.

The willingness to share and the task interdependence are both factors directly linked to the implicit coordination. Both factors imply that a higher score in willingness to share and a higher score in task interdependence lead to more informal contact and in this way enhances implicit coordination. The results of the SNA show an average score of 3,8 when it comes to the will to share information. The scores on task interdependence are a bit more scattered based on the input of the participants. This does not seem strange because not every role is equally central and therefore not as dependent on another. The SNA shows an average score of 2,9 when it comes to the task interdependence.

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5 COMPARISON INTENDED VS. ACTUAL INFORMATION FLOWS

This chapter will compare the intended information flow as provided in chapter 3 to the actual information flow as identified in chapter 4. This comparison will help finding the differences between the two information flows as is the main goal of the fourth sub-question.

5.1 CONSTRUCTIVE COMPARISON

In section 3.5, table 3.1 presents the contacts as is intended by Hollandia using the scores of either 0 (no contacts are present) or 1 (contacts are present). In order to be able to compare the intended and actual information flow a similar table is provided that shows the contact moments of the actual information flow, see table 5.1. The scores of 0 (no contacts are present) and 1-5 (contacts are present) are based on the results of the dimension 'frequency' of the Social Network Analysis. It is interesting to take the scores of 1-5 into account since this provides insight on how frequent contact moments occur. In table 5.1, three colours are used to indicate the similarities and differences with the intended information flow. Green means the score corresponds to table 3.1, red means that contacts should be present but are absent, yellow shows that contacts are not foreseen but are present.

Table 5.1: Comparison intended and actual information flows (appendix A contains the explanation of the abbreviations)
Explanation matrix: - Value 0: No contact moments present; Value 1-5: Contact moments present (appendix B shows the meaning of the 1-5 scores);
- A green score means the score corresponds with what was intended, a red score means that contact moments should be present but are absent, a yellow score shows that contact moments are not foreseen but are present.

	PM	PE	CM	MFAB	FOG (c)	FO (c#1)	FO (c#2)	FOG (w)	FO (w#1)	FO (w#2)	ILE	HIN	SUP	FO	QCE	QCI	PL	PN #1	PN #2	LGF	LGM
PM		5	5	1	0	0	0	0	0	0	3	1	0	0	3	4	1	4	2	0	1
PE			3	2	3	2	2	0	0	0	4	1	0	0	2	3	1	5	5	0	0
CM				3	4	2	1	4	3	3	1	2	0	2	2	2	3	3	3	2	2
MFAB					5	3	3	5	3	3	2	3	1	3	2	2	4	3	2	1	3
FOG (c)						5	5	5	4	4	0	1	0	2	2	2	2	4	4	2	4
FO (c#1)							5	5	5	5	0	0	0	1	0	1	2	4	4	4	2
FO (c#2)								5	5	5	0	0	0	1	0	1	0	4	4	4	2
FOG (w)									5	5	0	1	1	1	2	3	2	2	1	1	3
FO (w#1)										5	0	0	0	1	0	3	0	0	0	0	0
FO (w#2)											0	0	0	1	0	3	0	0	0	0	0
ILE												1	1	0	0	0	0	1	1	0	0
HIN													1	4	2	0	2	2	2	0	3
SUP														2	0	0	0	0	0	1	2
FO															0	0	1	1	1	2	4
QCE																4	0	1	1	0	0
QCI																	0	3	3	0	0
PL																		5	5	0	0
PN #1																			4	0	0
PN #2																				0	0
LGF																					5
LGM																					

5.2 DIFFERENCES IDENTIFIED

By comparing the intended and actual information flow, two types of differences have been identified. These two differences concern absent contacts and unforeseen contacts. The absent contacts are contacts that should have existed according to the intended information flow, but seem to be absent according to the results of the Social Network Analysis. The unforeseen contacts concern contacts that were not predicted by the intended information flow, but seem to exist nonetheless according to the results of the Social Network Analysis.

5.2.1 Absent contacts

Table 5, in section 5.1, shows a few contacts that, according to the intended information flow should be present but aren't according to the actual information flow based on the results of the SNA. The absent contacts are displayed as a red zero. These absent contacts are visualised in figure 5.1 and are elaborated on below.

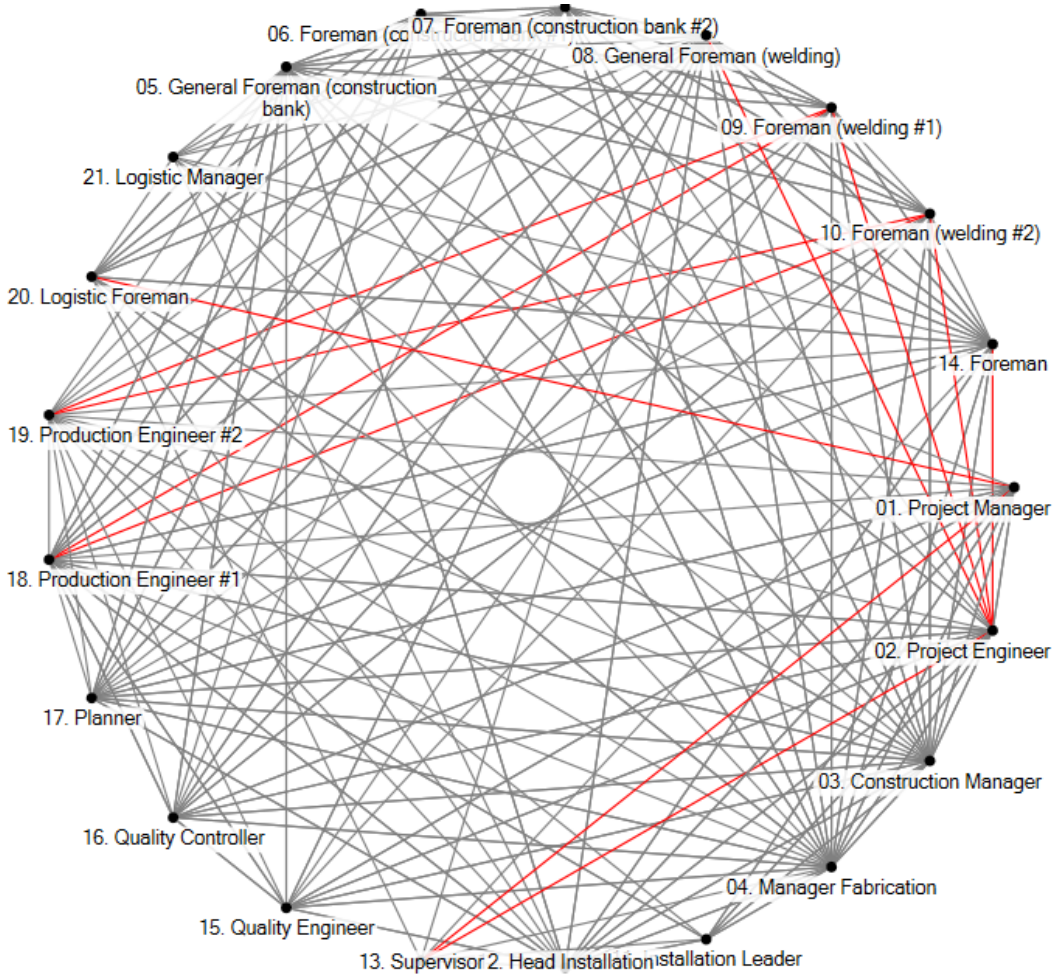

Figure 5.1: Absent contacts visualised with red lines
Source: Own illustration using NodeXL

As table 5.1 and figure 5.1 show, the project manager is expected to have contacts with the supervisor and the logistic foreman. However, the SNA shows that this is not the case and that these contacts are absent. Given the central role of a project manager this seems rather interesting. Since these information flows should formally be present, but are absent in practice.

The project engineer has a few absent contacts. The project engineer is expected to have contacts with the general foreman, the foremen and the supervisor. However, these contacts seem to be absent. It turns out that the process schemes of Hollandia do not distinguish between different foremen (construction and welding). According to these schemes the project engineer is expected to have contacts with the general foreman and foremen. The SNA shows that the project engineer actually has contact with these roles, but only when they are related to construction and not to welding. Given the fact that the process schemes of Hollandia do not make this distinction, these absent contacts are neglected. Therefore, the project engineer has one absent contacts with the supervisor.

Both foremen related to welding have absent contacts with the production engineers and the project manager. It is noticeable that the general foreman related to welding does have contacts with both production engineers. Given the fact that the process schemes of Hollandia do not distinguish between foremen and given the fact both production engineers do have contacts with the foremen related to construction, it is expected that contacts with the foremen related to welding were never supposed to be present at all. Therefore these are negligible as well.

5.2.2 Unforeseen contacts

Table 5.1 in section 5.1, also shows unforeseen contacts. These contacts are not present in the intended information flow, but according to the SNA results they do happen in practice. Figure 5.2 shows a visualisation of these unforeseen contacts by giving the corresponding edge the colour blue.

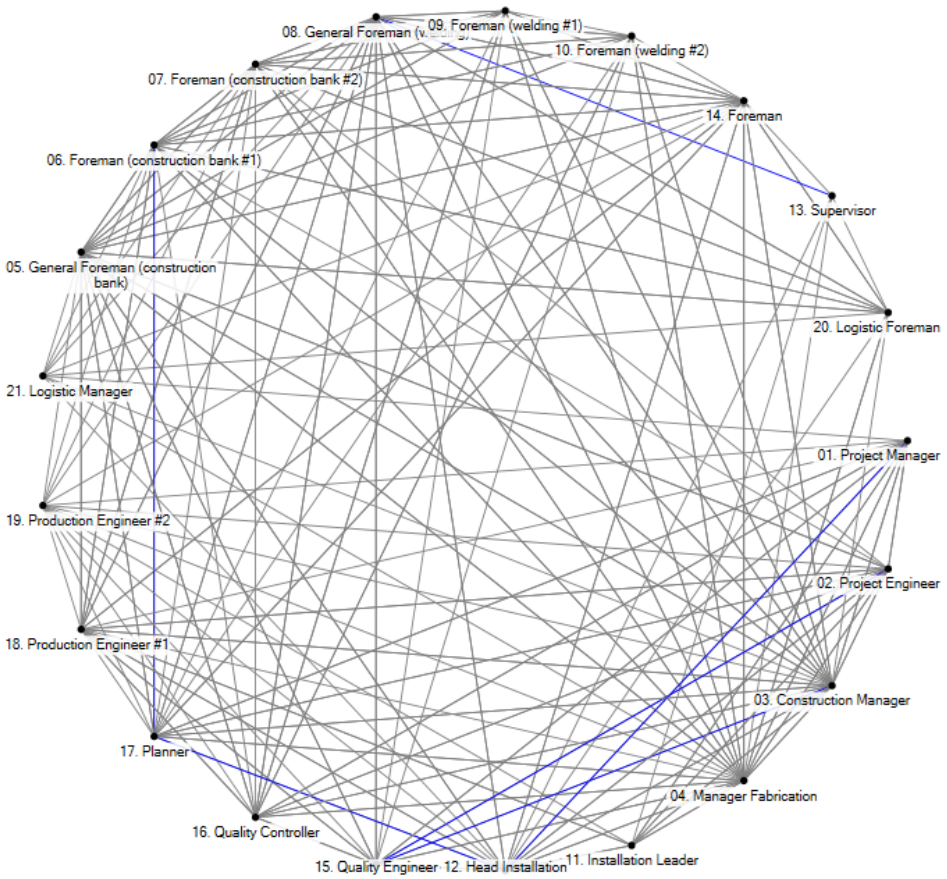

Figure 5.2: Unforeseen contacts visualised with the blue lines.
Source: Own illustration using NodeXL

Table 5.1, in section 5.1, shows the frequency results from the SNA study. This means that the score shows how frequently certain contacts occur. The meaning of the scores 1-5 that apply to frequency can be found in appendix B.

As table 5.1 and figure 5.2 show, the quality engineer (QCE) is not expected to have contacts with the project engineer and the construction manager. However, the SNA shows that these contacts still occur with a frequency of at least once a week. The centrality scores of the project engineer and the construction manager are very high, which indicates that both roles are relatively heavily loaded.

The planner is not expected to have contacts with the *head of installation* (HIN) and the foreman (construction #1). Still the SNA shows that these unforeseen contacts occur with a frequency of at least once a week. It is noticeable that the other foremen do not have this contact.

The last unforeseen contacts are related to the logistic foreman. This role is not expected to have contacts with the construction manager from the engineering department. However, the SNA shows that these contacts do exist with a frequency of once every week. The construction manager has one of the highest centrality scores and is therefore considered highly influential. The contacts between the logistic foreman and the construction manager are expected to be necessary to gather all the needed information.

5.3 COMPARISON CENTRALITY SCORES

Quantitative analyses were performed in this study, to investigate centrality, respectively for the intended information flow and for the actual information flow. This section will compare them to one another in order to find differences concerning the central position of the actors.

The centrality scores of the actors in the intended network of figure 3.6 in section 3.5.2 are compared to the centrality scores of the actors in the actual network of figure 4.2 in section 4.7, see figure 5.3. The orange dots present the centrality scores of the actors as is intended in the network. The blue dots present the centrality scores of the actors as the SNA suggests.

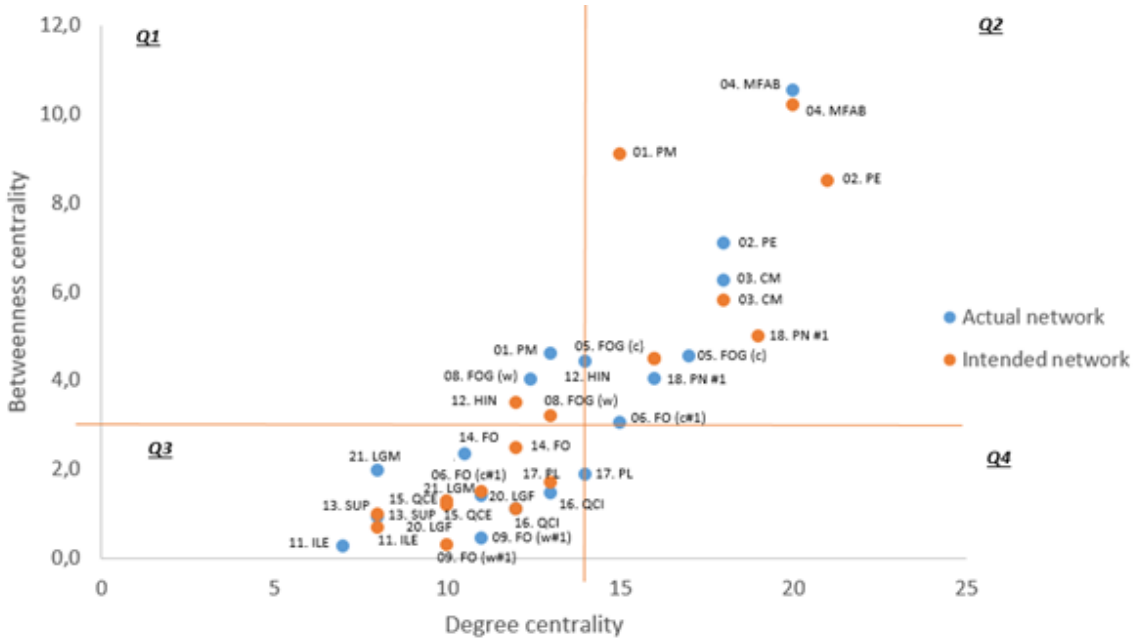

Figure 5.3: Four-quadrant centrality – Comparison intended network vs. actual network
Source: Own illustration using the centrality scores calculated using NodeXL

For most actors, the intended and actual network centrality scores seem to match. However, there are a few actors where this is not the case. This concerns the project manager and the project engineer. Both roles were expected to have a more central position. Especially the project manager has a far more central role in the intended network than the actual network, measured through the SNA.

Another role that stands out, but does not seem to differ between the intended and actual network, is the role of the manager of fabrications. The intended network suggests that the role of the manager of fabrication is the most central role. The SNA shows the same result. This raises the question whether this role is not overloaded and whether the actor who fulfils the role runs the risk of being overloaded.

5.4 CONCLUSION

This chapter compares the intended and actual information flow and aims to find the differences. This chapter helps answering sub-question 4.

Constructively comparing the intended information flow to the actual information flow, absent contacts and unforeseen contacts have been identified. Absent contacts are contacts that should have existed according to the intended information flow, but seem to be absent according to the SNA. The unforeseen contacts are contacts that were not expected according to the intended information flow, however do they actually exist according to the SNA. Although differences have been identified between the intended and actual information flow, the vast majority of the results of the SNA are consistent with the intended information flow. It can be concluded that the actual information flow, according to the SNA, deviates on a few aspects from the intended information flow.

Next to the constructive comparison, a quantitative comparison has been carried out. The quantitative analyses show the centrality scores of the actors, which implies how central their position is in the total network. Comparing the centrality scores of the intended and actual network a few differences have been identified. The differences concern the project manager and the project engineer. Especially the project manager has a far more central role in the intended network than the SNA suggests.

It can be concluded that the actual information flow, according to the SNA, reasonably corresponds to the intended information flow. However, a number of differences are noted that are striking. The absent contact moments are noticeable as the intended information flow is not followed here. This begs the question of why this is happening. It is also striking that the project manager, according to the SNA, has a for less central position than the intended information flow suggests.

6 CAUSES FOR DIFFERENCES AND WHAT TO IMPROVE

In order to understand why the identified differences between the intended and actual information flow occur, short interviews have been carried out with the practitioners involved in these differences. The first part of this chapter deals with the findings of these interviews. Later, this chapter presents managerial implications logically arising from the interviews that should help to enhance information flows.

The managerial implications have been validated by interviewing two experts. This part is explained in the penultimate section of this chapter.

6.1 INTERVIEW SETUP

In the previous chapter differences between the intended and actual network have been identified. The actors involved in these differences have been interviewed in order to understand why these differences occur, which comes down to a total of nine people, namely:

- The project manager;
- The project engineer;
- The construction manager;
- The manager of fabrications;
- The head of installation;
- The Quality engineer;
- The Planner;
- The logistic foreman;
- Foreman (construction bank #1).

The interviews were conducted in person and help to create a sense of what is going on in the workplace. Next to this, a few questions have been added to gain insight in the opinion the practitioners have on how information flows could be enhanced. The conclusions drawn from these interviews have been checked afterwards by the interviewees in order to reduce the chance of a misinterpretation by the interviewer.

The interview consists of four different clusters. Of course, not every cluster is applicable to every actor being interviewed. The four clusters concern:

- Questions related to absent contacts;
- Questions related to unforeseen contacts;
- Questions related to centrality scores;
- Questions related to the opinion on how to improve information flows.

The fourth cluster concerns questions related to the opinion of the workforce on how to improve the information flows. These questions have been asked to all interviewees. The other clusters were only applicable if the specific actor was present in this particular difference. The questions asked in these interviews can be found in appendix F.

6.2 INTERVIEW FINDINGS

This section deals with the interview findings. A more extensive version of the interview answers can be found in the appendix G. This chapter summarizes the conclusions drawn from the answers given by the interviewee. One person related to absent contacts has not been interviewed due to absence, this concerns the supervisor. To gain insight into these contacts, all involved actors were interviewed.

6.2.1 Interview findings – Absent contacts

This section deals with the interview findings concerning absent contacts. The reasons for this absent contact is explained per actor.

Project Manager (PM) related absents

As can be seen in figure 5.1, there are some absent contacts related to the role of 'project manager'. The role of project manager is expected to have contacts with the role of supervisor and the role of logistic foreman, however the SNA results indicate that this contact is absent. The first reason is that the logistic foreman is mainly responsible for overseeing the deliveries and shipments of incoming material, according to the project manager. The project manager is of course interested in the result of this, but is informed about this by the fabrication manager and the logistic manager and thus has no contact with the logistic foreman. The same can be said for the role of supervisor who is more in contact with other entities than Hollandia.

The project manager regrets that he has no contact with the workers in the production hall, but states that he does not have the time to do so and claims that he is still able to get the right information through other ways. When the project manager is asked why the intended procedure has been changed, he states that he thinks that he has to resolve too many conflicts in different departments and therefore simply does not get to the contacts with the workforce in the production hall.

It can be concluded that the project manager receives information from both these actors through other actors, especially from the fabrication manager and the logistic manager. The project manager fails to maintain contacts with the workers in the production hall which brings the risk of the project manager being out of touch with the project.

Project Engineer (PE) related absents

The role of project engineer can be described as the bridge between the project manager and the technical disciplines of the project. Figure 5.1 shows that a few absent contacts with other disciplines, especially with the general foreman and foremen related to welding and installation. It is noticeable that these contacts do exist with the comparable roles of general foreman and foremen related to construction. The main reason for this is that the project engineer's attention is mainly focused on the construction, as opposed to welding, since his role sometimes requires to elaborate on construction related matters. The welding and installation only come into effect after construction. The project engineer actually has nothing to do with this anymore. The reason that the intended information flow concludes that this contact must be present is because Hollandia's management system diagrams do not distinguish between different foremen roles.
Another absent contact is present between the project engineer and the supplier. This is mainly due to the phasing of the project. In a later state, this contact will most likely occur. Until then the project engineer receives information from the installation leader and the manager of fabrications.

It can be concluded that the project engineer, gains information through other actors than the intended information flow suggests. The fabrication manager and the installation leader play the most

important role in this. This means that the absent contacts get compensated. The intended information still gets transferred to the correct actor, only following a different route.

Logistic Foreman (LFG) related absent contacts

The logistic foreman is mainly responsible for overseeing the deliveries and shipments of incoming material. His role therefore mainly takes place in the factory hall and not in the office. Therefore the project manager and the logistic foreman do not see each other. The logistic foreman also states that the project manager never comes down to the production hall, which is why they never speak to one another. Next to this, the logistic manager informs the project manager about logistic related information, therefore formal contact with the logistic foreman seems unnecessary.

It can be concluded that the role of logistic foreman does not require information from the project manager as the logistic manager takes on this information flow. This is mainly due to the fact that the logistic foreman and the project manager never see one another as both do not visit the others work spot.

Foremen welding #1 & #2 related absent contacts

Both foremen seem to have absent contacts with both production engineers. However, this is due to the fact that Hollandia's management system diagrams do not distinguish between different foremen roles. This creates the impression as if a contact moment is absent here, while this is actually not the case. The foremen state that contacts with the production engineer do actually happen, however only in a later state of the project, when the role of welding increases.

It can be concluded that these contacts do actually exist, but have not yet occurred at the time of this research. In later stages it is expected that these contacts will occur.

6.2.2 Interview findings – Unforeseen contacts

This section deals with the interview findings concerning absent unforeseen contacts. The reasons for this unforeseen contact is explained per actor.

Project engineer (PE) related unforeseen contact with the quality engineer

The interview shows that this contact is especially strong in the initial phase, because the project engineer has to meet many quality requirements in this phase. The quality engineer has information that needs to be implemented in the construction drawings and keeping close contact lowers the chance on problems later on down the line. Later on during the production of the construction, the project engineer helps solving occurring errors.

It can be concluded that these informal unforeseen contacts contribute to the smooth running of the entire production process. The interviewee even states that these informal contacts are very important if not vital in order to execute the role of project engineer. This unforeseen contact provides additional information on top of what was intended.

Construction manager (CM) related unforeseen contacts

An unforeseen contact between the construction manager and the quality engineer occurs. The interview with the construction managers shows that this is mainly to gain insight into what else is needed to get the construction through production. This is the main concern of the construction manager in this stage and disappointing quality controls slow down the process. This is how the construction manager tries to prevent this.

Another unforeseen contact happens between the construction manager and the logistic foreman. The construction manager sees it as an added value to keep the logistic foreman informed when certain products are finished. Formally speaking, this is actually the task of the logistic manager. Next to this the construction manager likes to keep in touch with the logistic foreman, because this person informs more effectively than others. This is, of course, a personal opinion.

It can be concluded that these unforeseen informal information flows help smoothen the process by informing certain roles more quickly or more effective.

Quality engineer (QCE) related unforeseen contacts

The quality engineer is mainly responsible for designing quality standards which must be met, inspecting the quality of incoming materials and developing systems that can help to control the quality. In order to do this, the quality engineer mainly has contacts with the project manager and the managers in the construction hall, like the general foreman and the fabrication manager. However, in order to develop quality control systems it is rather obvious that the quality engineer would consult with the project engineer and construction manager about the quality standards. Next to this, the quality engineer contacts the project engineer when questions arise because something is not understood from the construction drawing and needs further explanation. Overall, the project engineer has the most knowledge on the technical and mechanical problems, which means this is often the shortest way to get the right information. The interview also shows that the quality engineer does not know exactly what the role of the construction manager entails.

It can be concluded that these unforeseen contacts help to gather the right information as quickly as possible. Concerning the actors directly linked to the information needed instead of intermediaries results in a better transfer of information.

Planner (PL) related unforeseen contacts

The planner is mainly concerned with managing the time schedule planning. This role takes care of the planning of all tasks and ensures that the project can be completed on time. The planner seems to have an unforeseen contact with the construction foreman. Normally the planner would only have contacts with the general foreman, who will later inform the foreman. The SNA however, shows that the construction foreman and the planner have contact at least once every week. According to the planner this contact occurs in order to gain insight in the progress of the project. The foreman who actually works on the construction of products knows best how much time is still needed. The foreman can thus inform the planner more effectively than for instance the manager of fabrications. This information could be retrieved through other actors as well, but consulting the foreman is quicker.

Another unforeseen contacts appears between the planner and the head of installation. According to the interviewee, this is because the head of installation has information about the required capacity. This information could also be retrieved from the Installation Leader, but the head of installation is on location and is thus better informed.

It can be concluded that the planner, gains some information through other actors than the intended information flow suggests in order to get certain information quicker or in a more effective way.

Logistic Foreman (LGF) related unforeseen contacts

The logistic foreman is mainly responsible for overseeing the deliveries and shipments of incoming material. Therefore the logistic foreman is mainly expected to have contacts with actors from production and installation departments. However, the SNA shows that an unforeseen contact exists between the logistic foreman and the construction manager. The construction manager is responsible for anything that happens to the product until it is finished, therefore the construction manager wants to be kept informed by the logistic manager about the complex transport movements. The direct relation between the logistic foreman and the construction manager therefore does not seem to be necessary, but the SNA shows that it exists.

Head of Installation (HIN) related unforeseen contacts

The head of installation has a contact with the planner that is not expected by the intended information flow. This is mainly due to the fact that the head of installation works on a specific location and likes to keep a short communication line with the planner in order to monitor the progress of the project. The head of installation also provides input on the planning schedule when activities take less or more time than initially thought. It can be concluded that this contact is not necessary, but informally helps smoothening the overall installation process.

Foreman construction bank #1 (FO c#1) related unforeseen contacts

The foreman related to the construction bank seems to have unforeseen contacts with the planner. The foreman has a close relationship with the general foreman. They often talk together with the planner, even though his position does not require it.

6.2.3 Interview findings – Centrality differences

This section deals with the interview findings concerning the differences identified in the quantitative analysis. In this section the findings from the interviews concerning the centrality differences are presented. These interviews were conducted with the project manager, the project engineer and the manager of fabrications.

Project manager

The SNA shows that the project manager fulfils a far less central role in comparison with the intended network. The reason the scores are lower is mainly due to the fact that the project manager is expected to have contacts with the workforce in the production hall, but the SNA shows that these contacts are absent. As a result, the project manager has fewer contacts than originally thought and this role ends less centrally than predicted. This raises the question of whether the project manager is out of touch with the project and whether he is capable of managing the project without knowing exactly what is going on in the production hall.

The project manager states that he is very so willing to invest in having more contacts with the workforce of the installation hall, but he does not have the time. He thinks that within Hollandia he is too busy putting out fires that are politically related instead of his work. As a result, he does not seem to have time to maintain these contacts properly. The project manager also states that it would be better for the coordination of the project to visit the installation hall and see the progress more often.

Project engineer

The SNA shows that the project engineer fulfils a less central role in comparison with the intended network. The reason the scores are lower is mainly due to the fact that the project engineer is expected to have contacts with the foremen of welding and the foreman of installation, however the SNA shows that these contacts are absent. As a result, the project manager has fewer contacts than originally thought and this role ends less centrally than predicted.

The project engineer states that contacts with the foremen related to welding is not necessary for him at all. It could be the case that in a later stage of the project these contacts still occur, but it does not seem likely. The same goes for the foreman related to installation. This in contrast to the foremen related to construction, whom he has contacts with. The project engineer states that there is no need for changes here, but he suggests that the intended process of Hollandia should distinguish between the different foremen, rather than seeing them all as the same.

Manager of fabrications

The quantitative analysis of the intended network shows that the role of manager of fabrications is the most central one. The SNA confirms this central position. This raises the question whether this role is not too centrally located and whether this role is not overloaded.

The manager of fabrications states that he indeed has a busy job. He acknowledges that it is very busy, but that he is able to deal with this. The manager of fabrications states that it would be welcome if his role would become a little less central. He now seems to be the central point of contact between the installation hall and the office. Logically speaking this is to be expected, but it would be better if both, the installation hall and the office, were a little more integrated into one other, so that the role of manager of fabrications is a little less burdened. He also states that this job is not a job that you have to do for years, given that it is probably too busy for this.

6.3 ENHANCING INFORMATION FLOWS

This section elaborates on the opinion of the workforce on how the information flows of Hollandia Infra could be enhanced and combines this with the literature found in chapter 2. This part mainly involves the opinion of the interviewees on information flows. It should be clear that the opinion of the interviewee cannot hold all knowledge, but the opinion of the workforce provides insight in how information flows can be enhanced in practice.

Information flow related question
The interviewee was asked to evaluate what he/she thinks is important for maintaining or improving the information flows. The most frequently given answer is that direct contact is far more appreciated than indirect contact, through for instance e-mail. According to the opinion of the interviewees the information flow is easier to maintain and even improved if direct contact with others happens more often. Next to this, several participants indicate that they find it very pleasant when people actively take the time for you. In line with this is the shared view that hierarchy should not play a role in informal contact. Everyone should be able to ask questions to everybody.

The interviewees also indicate that they have many informal connections with colleagues. These informal contacts directly contribute to the transfer of additional information. The quality engineer even claims that functioning without the informal flow of information would be impossible.

Another finding from the information flow related question indicates that Hollandia Infra has put a lot of effort in developing the informal information flow with the intention that this would result in good end results. However, this has also resulted in the development of how to deal with the formal information flow lagging behind. The workforce believes that modernizing the technology that helps to capture formal information flows should be invested in, as it can be hard to draw information from it.

Willingness to share information related question
The interviewees were asked to evaluate on how their willingness to share is influenced by their colleagues. Three frequently mentioned factors are:

- A feeling of trust;
- Knowing colleagues personally;
- No blame culture.

The literature in section 2.4, already mentions trust to be an important factor that influences the willingness to share (Imam & Zaheer, 2021). The interviewees argue that it is important that someone does not misuse shared information. In line with this lies, knowing colleagues personally also contribute to the willingness to share information according to the interviewees. The literature argues this as well by claiming that the longer people work together, the more the relationships get the chance to grow and thus positively affect the willingness to share (Langan-Fox et al, 2004). Several participants stated that they actually don't know enough people personally and that it would help if they did. For example, they believe that more could be done on team building to create better mutual relationships. The last factor named by the interviewees is the absence of a blame culture. This is in line with the feeling of trust in which a culture is created of openness which offers the possibility to ask questions.

6.4 MANAGERIAL IMPLICATIONS

The interview findings have been translated to managerial implications by looking at how often certain answers have been given. These managerial implications can be applied in practice and show exactly what needs to be done. By studying the interview findings, there are three clusters in which all managerial implications can be subdivided. These clusters concern: staffing, formal adjustments and investments. The managerial implications are based on the answers that were given most frequently in the interviews, and are validated during expert meetings. All managerial implications that have been found in this research are stated in this section. The order in which they are mentioned is meaningless. In total there are ten managerial implications.

Cluster 1: Staffing

1. ***The project manager must maintain frequent contact with the workforce in the production hall.***

The comparison between the intended and actual information flow shows that the contact moments between the project manager and the workforce in the production hall is absent. Due to this absence the centrality scores of the project manager are lower than is intended. The project manager states that he does not have the time to maintain these contacts and that is able to get the right information in other ways. This way of working creates the risk that the project manager is out of touch with the project as he has no personal touch with the workforce and does not actually see what is going on. Therefore, the project manager should maintain frequent contacts with the workforce in the production hall, which will improve the information flow and overall coordination of the project as the project manager will be more involved in the process.

2. ***The role of manager of fabrication must be less central in order to prevent a burn out.***

The quantitative analysis of the intended network shows that the manager of fabrication fulfils the most central position in the network. The quantitative analysis of the actual network shows the same result. The centrality position of the manager of fabrication appears to be very high, which may indicate an overload. An interview with the manager of fabrication confirms that this role is under pressure and that this person is actually too busy to properly perform all his duties. The role of manager of fabrication should therefore be adjusted to a less central role, by for instance increasing the centrality of the project manager. This means that the formal process will have to be adjusted in order to achieve this managerial implication.

Cluster 2: Formal process

3. ***The formal process must distinguish between different foremen roles.***

The formal processes of Hollandia Infra do not distinguish between the different types of foremen while there are several, like construction, welding and installation. This makes it unclear which foreman should be contacted. The formal process should therefore be adjusted in order to include these differences.

4. ***Focus on a relationship-oriented approach.***

The Social Network Analysis shows that the overall status of the relationships is well developed. However, the interviews showed that some roles still do not feel fully appreciated. More attention should go out to the people from quality engineering. Improving the relationship between management related roles and the quality-related roles can help avoiding problems in the early stages of the project.

5. Involve roles early on in the project.

The research shows that the scores on task interdependence between the participants of the social network survey are quite scattered. This means that not all roles occupy an equally crucial position within the project team. This does not seem strange, however, the literature claims that the more task dependence there is, the more contact is required (Bertucci et al, 2016). This benefits the implicit coordination. Therefore Hollandia should invest in involving the different roles, including the ones with a lower task interdependence score, in order to make sure everyone is involved in the project.

6. Create awareness on everyone's role and position.

The results of the interview show that not everyone is completely aware of the exact function of other roles. For instance, the quality engineer does not seem to understand what the function of the construction manager is as a whole. Hollandia should invest in creating awareness on all the functions and what the position is of everyone. Creating a common understanding on each other's function and responsibilities may result in mutual understanding and better personal relationships. In this way it is also more clear to team members which information is interesting for other actors.

7. Replace central actors with care.

The quantitative analysis of the Social Network shows the most important and central actors in the network. Within Hollandia Infra, people sometimes leave and they need to be replaced. Replacing the most central actors should be done with care, as the new actor may not hold the same knowledge and skills as the actor that is replaced. Hollandia Infra must make sure that this replacement procedure runs as smoothly as possible.

Cluster 3: Investments

8. Invest in awareness on energizing one another.

The Social Network Analysis shows that the project team has no energizing effect, however neither does it de-energize. By creating awareness among the project team that a certain attitude or reaction can sometimes deliver more results, the energy level may increase. This positive atmosphere is good for the overall relationships and thus the informal flow of information.

9. Invest in creating a balance between the formal and informal information flows and the role they should fulfil.

This study shows that informal information flows help to close the gaps in the formal intended information flow. Observing the importance of the informal information flow, companies should address the role the informal information flow should have in their organisation. Organisations should invest in creating a balance between the formal and informal information flows and the role they should fulfil. Investing in the informal information flow, given its importance, should not rule out investing in the development of the formal information flow.

10. Invest in modern technology concerning the development of formal information flows.

The interview findings suggest that the management of Hollandia Infra mainly invested in the informal information flow. This has resulted in it being highly developed and everyone has a very pleasant work experience. However, as a result, little has been invested in a modern way of dealing with the formal information flow. Since the informal flow of information is difficult to trace, there must be a good formal flow of information that can serve as a basis. Modern technical possibilities should be explored on how to cope with these formal information flows.

6.5 VALIDATION / EXPERT MEETING

The managerial implications that come forward based on the interview findings are validated during two expert meetings. This validation process takes place in order to make sure that the managerial implications are recognised as important or unimportant in order to improve the information flows. As a result of these expert meetings it can be concluded which three managerial implications are most important.
Both experts indicate that the managerial implications logically originate from the interview findings and state that all are very recognisable. Not every managerial implication is seen as equally important. This provides insight into which managerial implications are most important. During the meetings some rephrasing and textual adjustments were made.

The expert meeting method is explained in section 1.4 and the conclusions drawn from these interviews can be found in appendix H2 and appendix H3.

The experts
The first expert fulfils the role of director and has been working at Hollandia for thirty years. In these thirty years he has fulfilled roles at all levels and he himself has conducted a master's research into information flows. For this reason, this expert is a good choice to validate the results.

The second expert is a board member of Hollandia Infra. This expert has been working at Hollandia for 25 years and has fulfilled roles in various departments. Due to his long employment and many years of experience, this expert is also very suitable for validating the process.

Most important three managerial implications
Since focussing on all ten managerial implications (MI) is impossible, the most important ones in order to enhance the information flows of Hollandia Infra are identified in the expert meetings. The three most important managerial implications are:

- MI01: The project manager must maintain frequent contact with the workforce in the production hall.
- MI02: The role of manager of fabrication must be less central in order to prevent a burn out.
- MI09: Invest in creating a balance between the formal and informal information flows and the role they should fulfil.

In order to help enhancing the information flows within a construction project within a construction company, these three managerial implications are deemed to be applied.

6.6 Conclusion

This chapter analyses the results from the questions asked to the participants of the SNA survey that are involved in an absent or unforeseen contacts and focusses on the actors that are involved in differences identified concerning the quantitative analyses conducted in this research. This way it has become clear why certain differences are present. Next to this a few questions have been added related to the possible enhancement of information flows. The interviews provide insight in why certain differences occur and how information flows can be enhanced, which is the goal of sub-question 5.

Analysing the results from the interviews, it can be stated that the project manager desires to have more contacts with the workforce in the installation hall. However, the project manager claims he has no time to actually see to this even though he states that this information flow would improve the overall coordination of the project. Next to this, it can be concluded that the role of manager of operations runs the risk of being overloaded. The high pressure on the actor fulfilling this role may have bad consequences on the long run. The manager of fabrications states that it would be welcome if his role would become a little less central. He now seems to be the central point of contact between the installation hall and the office. Logically speaking this is to be expected, but it would be better if both, the installation hall and the office, were a little more integrated into one other, so that the role of manager of fabrications is a little less burdened.

Analysing the results from the interviews, ten managerial implications have been created that could help improving information flow related issues. The three most important managerial implications have been determined in expert meetings and are listed below:

- MI01: The project manager must maintain frequent contact with the workforce in the production hall.
- MI02: The role of manager of fabrication must be less central in order to prevent a burn out.
- MI09: Invest in creating a balance between the formal and informal information flows and the role they should fulfil.

In order to help enhancing the information flows within a construction project within a construction company, these three managerial implications are deemed to be applied.

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7 DISCUSSION

This chapter concerns the discussion arising from this research. It will start by emphasizing what the theoretical contribution of this research has been. Following this, this research also serves a practical contribution. Lastly the research limitations are discussed.

7.1 THEORETICAL CONTRIBUTION

This research is essentially of a practical nature and contribution. However, a theoretical contribution is also made. This section discusses the theoretical contribution.

In this research a Social Network Analysis was conducted. The method of Cross et al, 2010, used in performing the SNA is not entirely without difficulties. The difficulties found are:

- There is no prescribed method on how to cope with the results and scores that this method produces as an end result. This study theoretically contributes by showing a way on how the results of the method of Cross can be analysed. In its current form this method lacks a preconceived way to interpret what the results exactly mean. This study also suggests that this specific aspect of the method of Cross should be elaborated in future research. A theoretical framework and method of coping with the results of the SNA performed with method of Cross should be elaborated. This has not been done in this specific research, but is very interesting and recommended for future research;
- The method of Cross, 2010, relies entirely on the data of the respondents. This means that the result depends heavily on the image that the respondents provide. There is a potential inaccuracy here as it is not very intersubjective. The score of what one thinks is difficult to relate to the score of another. The question here is whether all respondents use the same standard when filling in the questionnaire. Theoretically, there is room for improvement. This study shows a method for analysing the results. However, how to deal with the meaning and perspective of the score should be explored in future research.
- The method of Cross et all, 2010, is capable of capturing a moment when it comes to the status of the relationships. However, it fails to capture the evolution and improvement of the status of the relationships over time. It seems that this tool cannot be used properly to achieve improvement. This makes the method sufficient for a limited purpose. However, it should be taken into account that when the goal is an improvement, investments should be made in different methods that measure the network over time.

The theoretical added value of this study is the observation that there are some implicit inaccuracies in the method of Cross, 2010. This has emerged by applying the method and analysing the results.

7.2 PRACTICAL CONTRIBUTION

This research was carried out within the organisation of Hollandia Infra. For this reason, the research also has a very practical side and it seems appropriate to explain what this research delivers Hollandia Infra. This is explained in this section, however more detailed recommendations to Hollandia Infra can be found in chapter 8.

First of all, the research delivers Hollandia Infra managerial implications on what to focus on in order to enhance the information flows. These managerial implications show the importance of people in the organisation. Hollandia Infra has already invested in the social network experience by creating a special program called the Hollandia Infra Leadership School (HILS). This concerns a relationship-oriented approach where the idea is that the results will come naturally if the mutual relationships and working atmosphere function optimally. This study confirms this idea and approach.

The Social Network Analysis shows the position of Hollandia Infra in relation to various factors (frequency, responsiveness, effectiveness and energy) based on the method of Cross et al, 2010. The two added implicit coordination related factors also provide insight in the position of Hollandia Infra in relation to the willingness to share and task interdependence. The score on the willingness to share shows the healthy state of the informal information flow and the mutual relationships.

As a result of this entire research, managerial implications are provided to Hollandia Infra that help enhancing the information flows. These managerial implications concern both actions that should be taken and points for attention for the future. A very important finding of the interviews conducted with the workforce is the lagging development of the recording of the formal information flow. As much has been invested in social relations and the informal information flow by Hollandia Infra, documenting the formal information flow may have been forgotten. In practice, this formal information flow often serves as a basis and therefore the development of this formal information flow should be revisited.

7.3 RESEARCH LIMITATIONS

Every study has its limitations and as a consequence, interesting aspects are omitted from the analysis. Also, other problems or shortcomings during the study may have played a role that limited the study as a whole. The limitations of this study are stated below:

- **Small participants group:** The Social Network Analysis has been conducted using a survey. In total, 21 participants, together forming the project team, have filled in this survey. This is a relatively small group for a Social Network Analysis. With a larger group, more differences are likely to be found when the comparison between the intended and actual information flow is drawn up.

- **Based on one situation:** The conclusions and recommendations of this study are all based on this one project team in this one construction related project. This means that the conclusions have not been weighed up against multiple other projects within Hollandia Infra, let alone other companies with different corporate structures and cultures.

- **SNA over time:** The Social Network Analysis is conducted using a survey which provides insight in the actual information flow as it takes place at that particular moment in time. However, the construction phase, which was central to this research, lasts much longer than this one moment. It is possible that the information flows also change with the passage of time. This change over time has not been taken into account in this study.

- **Research methodology:** Due to the chosen research method of a Social Network Analysis the end results of this study reflect upon what to focus on regarding the information flow in order to enhance the coordination. The reflections and recommendations mainly focus on the social aspect of information flows and leave something to be desired with regard to formal information flows. The results from the literature study and the chosen research method play a key part in why the social aspects of information flow ended up playing a bigger role in this research.

- **Interviews:** The interviews conducted with the participants involved in the differences concluded from the comparison between the intended and actual information flow result in opinions of the workforce. However, these opinions are only provided by one person per role. It may be the case that certain views and opinions depend on the personality of the person.

- **Absent intended roles:** Not all roles that have been identified as important in the intended information flow are fulfilled in this particular project. This benchmark project was initiated by Hollandia Infra itself. It can be stated that there is not one project that perfectly fulfils all roles as intended. However, given the fact that one project served as a benchmark project for Hollandia Infra given that not all roles are fulfilled begs the question whether this project is fit to serve as the foundation of this research.

- **Shortcoming SNA:** When a contact between two actors is present, the SNA can only confirm or deny the existence of this contact. This does mean, however, that informal contacts that take place between two actors who already have formal contact are not demonstrated. This is a shortcoming of the SNA methodology in this research.

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8 CONCLUSIONS & RECOMMENDATIONS

In this chapter the conclusions of this study are presented. First of all, section 8.1 answers the sub-questions posed, after which section 8.2 answers the main question. The last part of this chapter concerns recommendations on further research.

8.1 CONCLUSION SUB-QUESTIONS

Sub-question 1
SQ: *'What role does literature accord to information flows in construction projects within a construction company?'*

Information flows are the route the information travels between different departments or individuals. Information flows can be divided into formal and informal information flows. Formal information flows is less dependent on individual information holders and functions according the agreed means, like for instance construction drawings. Informal information flows are far more dependent on individual knowledge and ones willingness to share this information.

The theoretical role of information flows in intrafirm supply chains of construction projects comes down to organisations providing generic formal information and guidelines that contribute to the functioning of the organisation. These formal information flows are supplemented by the informal information flow which plays a role in the background. According to the literature, the formal information flow dominates the informal information flow within construction companies. These construction companies tend to invest much more in developing the formal information flow than improving and developing the informal information flow. However, given the critical effect of informal information flows, organisations should manage the informal information flow as serious as the formal information systems.

Sub-question 2
SQ: *'What is the intended information flow?'*

The intended information flow of Hollandia Infra has been attempted by carrying out a company document study from which a workflow model emerges. At the beginning of this chapter the procedure to substantiate the workflow model for the construction phase was explained. The first step concerned defining the scope which showed that the relevant entity-types are: the actions undertaken by the actors, the information flow and the actors consulted and whom they inform. The next natural step concerned the understanding of the organizational structures that together form Hollandia Infra's process. It turned out that the engineering, production and installation departments constitute the primary process for the construction phase. A few supporting processes are vital in completing the primary process, which is why they are included as well. By understanding this primary process, the workflow was visualized.
Understanding and visualising the workflow and what the function of the different actors is, has led to the disclosure of the mutual relationships and the associated information flow. Based on the workflow it can be assumed who is in contact with whom. These contact moments are shown in section 3.5 using a binary matrix consisting of the two values 0 and 1. This shows which actors are intended to be in contact with one another.

Sub-question 3
SQ: *'What is the actual information flow?'*

The actual information flow of Hollandia Infra was investigated by carrying out a Social Network Analysis, which provides insight in how information actually flows through the project team. However, the goal of this research is to understand how information flows can be enhanced. So it didn't seem enough to just look at the presence or absence of contact. Therefore the status of the relationship needed to be captured as well. Cross et al (2010), created four different dimensions (frequency, responsiveness, effectiveness and energy) to capture the nature of a relation within an organisation. The SNA was executed using a survey which was extended by adding two implicit coordination related factors provided by the literature. These added factors concern *the willingness to share* and *task interdependence.*

Studying the results of the Social Network Analysis and mapping which actors are in contact with whom, has led to the actual information flow. The contacts that actually occur according to the results of the Social Network Analysis are provided in table 4.4 in section 4.6 and help to outline how the actual information flow works.

Sub-question 4
SQ: *'What is the difference between the intended and actual information flow?'*

Constructively comparing the intended information flow to the actual information flow, absent contacts and unforeseen contacts have been identified. Absent contacts are contacts that should have existed according to the intended information flow, but seem to be absent according to the SNA. The unforeseen contacts are contacts that were not expected according to the intended information flow, however do they actually exist according to the SNA. Although differences have been identified between the intended and actual information flow, the vast majority of the results of the SNA are consistent with the intended information flow. It can be concluded that the actual information flow, according to the SNA, deviates from the intended information flow, but fewer differences have been shown than originally stated by the literature.

Next to the constructive comparison, a quantitative comparison has been carried out. The quantitative analyses show the centrality scores of the actors, which implies how central their position is in the total network. Comparing the centrality scores of the intended and actual network a few differences have been identified. The largest differences are found at the project manager, the project engineer, the general foreman (welding) and the foreman (installation). Except for the general foreman (welding) and the foreman (installation) all roles were expected to have a more central position. Especially the project manager has a far more central role in the intended network than the SNA suggests.

It can be concluded that the actual information flow, according to the SNA, reasonably corresponds to the intended information flow. However, a number of differences are noted that are striking. The absent contact moments are noticeable as the intended information flow is not followed here. This begs the question of why this is happening. It is also striking that the project manager, according to the SNA, has a for less central position than initiated by the intended information flow.

Sub-question 5

SQ: *'What are important causes that may explain the differences between the intended and actual information flow?'*

Based on the interviews, it is concluded that the project manager desires to have more contacts with the workforce in the installation hall. However, the project manager claims he has no time to actually see to this even though he states that this information flow would improve the overall coordination of the project.

Next to this, it can be concluded that the role of manager of operations runs the risk of being overloaded. The high pressure on the actor fulfilling this role may have bad consequences on the long run. The manager of fabrications states that it would be welcome if his role would become a little less central. He now seems to be the central point of contact between the installation hall and the office. Logically speaking this is to be expected, but it would be better if both, the installation hall and the office, were a little more integrated into one other, so that the role of manager of fabrications is a little less burdened.

The final conclusion is that the interviews show that there is a strong informal network within Hollandia. This informal network helps to fill the gaps in the formal process. Analysing the results from the interviews, ten managerial implications have been created that could help improving information flow related issues. Three clusters were created to capture all ten managerial implications. These three clusters concern: staffing, formal adjustments and investments.

8.2 CONCLUSION MAIN RESEARCH QUESTION

The main research question in this study is:

'How can information flows be enhanced
in construction projects within a construction company?'

This study showed ten managerial implications for Hollandia Infra divided into three clusters, namely: staffing, formal process and investments. To answer the main research question of this study, these three clusters will be used to provide the answer.

Staffing
This study revealed that communication between the production hall and the office is of great importance. However, in practice this communication is not without problems. Neglecting this communication between the construction hall and the office causes a shift in the information flow. As a result, the formal process is not maintained and information has to find its way via other actors. This allows certain actors to take on a more crucial role in the network than originally intended. At the same time, some other roles become less central than originally intended.

In addition, it is important for the project management to be in close contact with what is happening in the production halls. Otherwise they run the risk of getting out of touch with the project. Therefore it can be concluded that project managers should maintain frequent contact with the workforce in the production halls.

Formal process
It is very important that all actors in the network are aware of each other's function. This is not always the case, which means that the actors are not able to provide each other with the correct information. It is important for organisations that every actor is well aware of the function of another actor. This ensures that everyone understands who benefits from which information.

Investments
This study found that there is a discrepancy between formal and informal information flows. The informal information flows help to close the gaps in the formal intended information flow. Observing the importance of the informal information flow, companies should address the role the informal information flow should have in their organisation. Organisations need to invest in creating a balance between the formal and informal information flows and the role they should fulfil.

8.3 RECOMMENDATIONS

Studying the results of the Social Network Analysis it can be concluded that the participants of the survey have high scores on the relationship components. This indicates that the mutual relationships within the Hollandia project team are well developed. Nevertheless, the research shows a number of results that Hollandia is advised to pay attention to. The first section will pay special attention to the recommendations to Hollandia Infra. The second section will elaborate on recommendations on future research.

8.3.1 Recommendations to Hollandia Infra

This section shows the recommendations made to Hollandia Infra based on the results of this research. Each recommendations is shortly explained.

Enhancing the information flow

Hollandia Infra is advised to apply and focus on the managerial implications in order to enhance the information flow. Focusing on all ten managerial implications would be ultimate, however focusing on ten managerial implications at once can be a tough challenge. Therefore, the three most important managerial implications should be implemented, which are:

- MI01: The project manager must maintain frequent contact with the workforce in the production hall.
- MI02: The role of manager of fabrication must be less central in order to prevent a burn out.
- MI09: Invest in creating a balance between the formal and informal information flows and the role they should fulfil.

In order to help enhancing the information flows within a construction project within a construction company, these three managerial implications are deemed to be applied.

Adjusting the formal process

Hollandia Infra is advised to adjust the formal process on two specific aspects:

- The documents that describe the formal processes should distinguish between the different foremen roles;
- The central role of the manger of fabrications should be reconsidered in order to reduce the workload on this role.

Investing in the development of the formal information flow

The interviewees claim that Hollandia Infra has invested in the development of relationships between colleagues, stimulating the informal information flow. This was done with the underlying idea that the results will come naturally if the working atmosphere and mutual interrelationship are of a high level. As a result, the interviewees do conclude that the development of capturing the formal information flow has lagged behind.

Hollandia Infra is advised to invest in the development of the formal information flow as the interview findings show that this development is lacking behind. Modern techniques and software should be explored in order to develop the formal information flow of Hollandia Infra.

8.3.2 Recommendations for future research

This section provides recommendations on future research. Each recommendations is shortly explained.

- ***Application of implicit coordination related factors***

The literature shows a framework for team implicit coordination processes as provided by Rico et al, 2008. Two factors, willingness to share and task interdependence, of this framework have been explored and investigated in this study. It is recommended that the applicability of all of these factors is explored in future research. This future study should investigate how these factors can be applied to improve the implicit coordination, as this current study mainly focused on the information flows and how these contribute to enhancing the coordination.

- ***Further elaboration of the method of Cross et al, 2010***

Cross et al (2010), created four different dimensions (frequency, responsiveness, effectiveness and energy) to capture the nature of a relation within an organisation. However, this method leaves much to be desired. It is recommended that research is carried out on how to properly cope with the results of this method. A theoretical framework and method of coping with the results of the SNA performed with method of Cross should be researched in future studies.

- ***Address the role informal information flows should have***

This study clearly shows that organisations benefit from having a well-developed informal information flow. However, future research should be about creating a balance between the formal and informal information flows. Both information flows turn out to be important sources of information. Development should not be focused on just one of these two and therefore a balance should be created.

- ***Studying modern technology systems concerning formal information flows***

The method used to conduct this research leaves something to be desired when it comes to modern techniques concerning the formal information flow. Future research should investigate how formal information flows that can be captured with modern technological means in order to improve the coordination of an organisation.

- ***Take individual cultural backgrounds into account***

The way in which the Social Network Analysis was performed and the method of Cross et al, 2010, do not take into account the cultural background of the participants when analysing the status of the relationships. Future research should explore how the cultural background can be implemented as construction companies often operate on international level. In this specific research the cultural background is less of a problem as Hollandia Infra mostly operates within the Netherlands and direct neighbour countries such as England. Nevertheless, Hollandia is not a benchmark for all construction companies in this regard. Therefore this crucial aspect should be investigated in future research.

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APPENDICES

APPENDIX A: EXPLANATION ABBREVIATIONS FUNCTIONS OF ACTORS

Table A1: Explanation abbreviations functions of actors.

Abbreviation	Clarification
ASM	Assembly Manager
CM	Construction Manager
DE	Design Engineer
DEM	Design and Engineering Manager
DIR	Director
DRDE	Draught Design Engineer
DRE	Draught Engineer
FABM	Fabrication Manager
FO	Foreman (installation)
FOG	Foreman General
HIN	Head Installation
ILE	Installation Leader
LGF	Logistic Foreman
LGM	Logistic Manager
MFAB	Manager Fabrication
MSHE	Manager SHE & Quality
PE	Project Engineer
PN	Production Engineer
PL	Planner
PM	Project Manager
QCE	Quality Engineer
QCI	Quality Controller
SUP	Supervisor

APPENDIX B: SOCIAL NETWORK ANALYSIS SURVEY

Table B1: Participants SNA survey

Number	Participant	Function
1	[redacted]	Project manager
2	[redacted]	Head project engineer
3	[redacted]	Construction manager
4	[redacted]	Manager fabrication
5	[redacted]	General foreman (construction bank)
6	[redacted]	Foreman (construction bank)
7	[redacted]	Foreman (construction bank)
8	[redacted]	General foreman (welding)
9	[redacted]	Foreman (welding)
10	[redacted]	Foreman (welding)
11	[redacted]	Installation leader
12	[redacted]	Head installation
13	[redacted]	Supervisor
14	[redacted]	Foreman (installation)
15	[redacted]	Quality engineer
16	[redacted]	Quality checker
17	[redacted]	Planner
18	[redacted]	Production engineer
19	[redacted]	Production engineer
20	[redacted]	Logistic foreman
21	[redacted]	Logistic manager

Table B2: Score list SNA

	Frequency	Responsiveness	Effectiveness	Energy	Willingness to share	Task interdependence
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
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15						
16						
17						
18						
19						
20						
21						

Table B3: Explanation scores – Frequency
Source: Adjusted from Cross et al, 2010

Please indicate the frequency with which you typically turn to each person for assistance on work-related issues.	
0	I do not know this person / Not applicable;
1	At least monthly;
2	At least weekly;
3	At least every 2-3 days;
4	At least every day;
5	Multiple times a day.

Table B4: Explanation scores – Responsiveness
Source: (Cross et al, 2010)

Please indicate the responsiveness of each individual in replying to your requests for work-related assistance.	
0	I do not know this person / Not applicable;
1	Often fails to respond;
2	Usually responds, but slowly;
3	Generally responds within a week;
4	Typically responds within 24 hours;
5	Always responds the same day.

Table B5: Explanation scores – Effectiveness
Source: (Cross et al, 2010)

How effective is each person in helping you solve work-related problems when they respond?	
0	I do not know this person / Not applicable;
1	Very ineffective;
2	Ineffective;
3	Reasonably effective;
4	Very effective;
5	Exceptionally effective.

Table B6: Explanation scores – Energy
Source: (Cross et al, 2010)

When you interact with this person, how does it affect your energy level?	
0	I do not know this person / Not applicable;
1	Very de-energizing;
2	Slightly de-energizing;
3	No effect / Neutral;
4	Slightly energizing;
5	Very energizing.

Table B7: Explanation scores – Willingness to share

Please indicate to what level you are willing to share work-related information with each person.	
0	I do not know this person / Not applicable;
1	You are not willing to share any information;
2	You are not willing to share more information than necessary;
3	You are willing to share upon request;
4	You are pro-actively sharing relevant information;
5	You will share everything with this person.

Table B8: Explanation scores – Task Interdependence

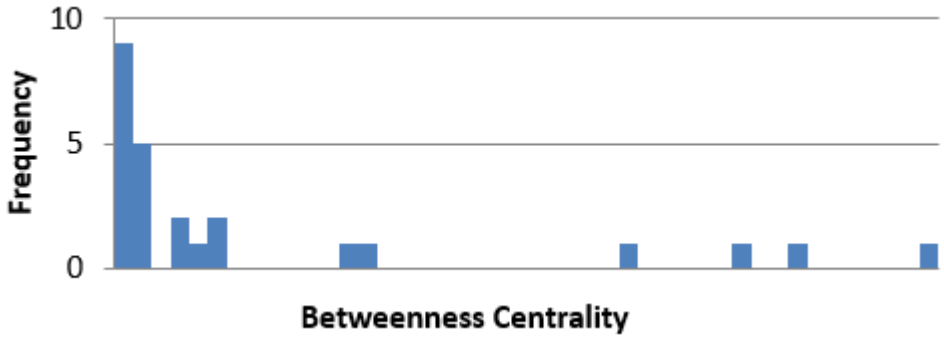
To what extent are your work-related tasks dependent on each person?	
0	I do not know this person / Not applicable;
1	Your tasks are not dependent;
2	Your tasks are not dependent on … , except for some exceptions;
3	Your tasks are moderately dependent on … ;
4	Your tasks are highly dependent on … ;
5	Your tasks are fully dependent on … .

APPENDIX C: CALCULATION RESULTS FOUR CENTRALITY PARAMETERS

In this appendix:

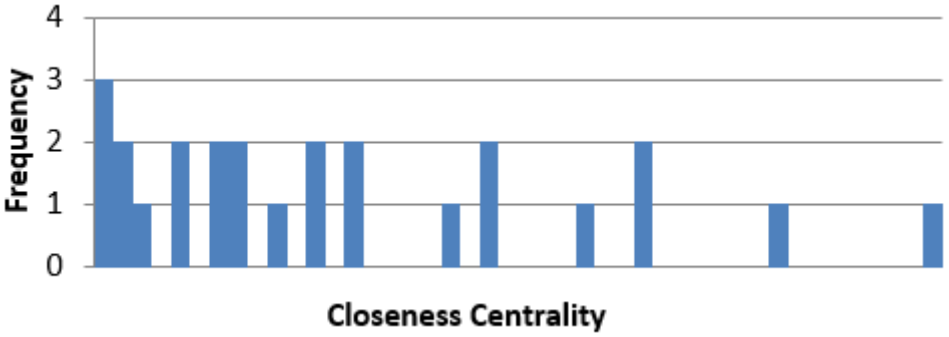
- Appendix C1: Centrality measures intended information flow;
- Appendix C2: Centrality measures actual information flow.

Appendix C1 – Centrality measures intended information flow



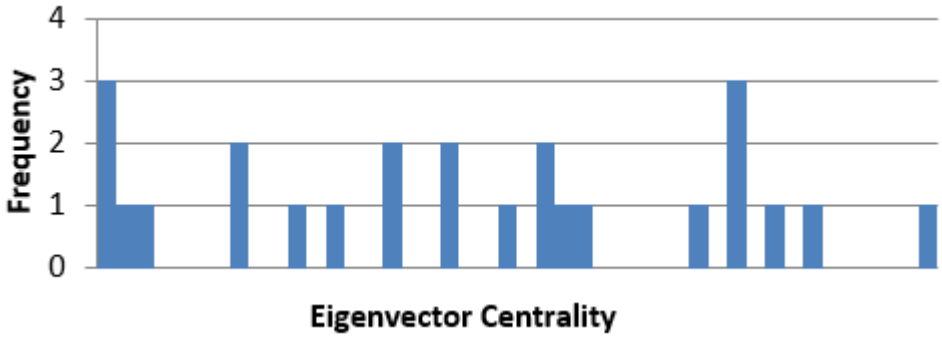
Minimum Betweenness Centrality	0,063
Maximum Betweenness Centrality	32,209
Average Betweenness Centrality	6,080
Median Betweenness Centrality	1,324

Figure C1.1: Betweenness centrality scores – intended information flow



Minimum Closeness Centrality	0,023
Maximum Closeness Centrality	0,040
Average Closeness Centrality	0,028
Median Closeness Centrality	0,027

Figure C1.2: Closeness centrality scores – intended information flow



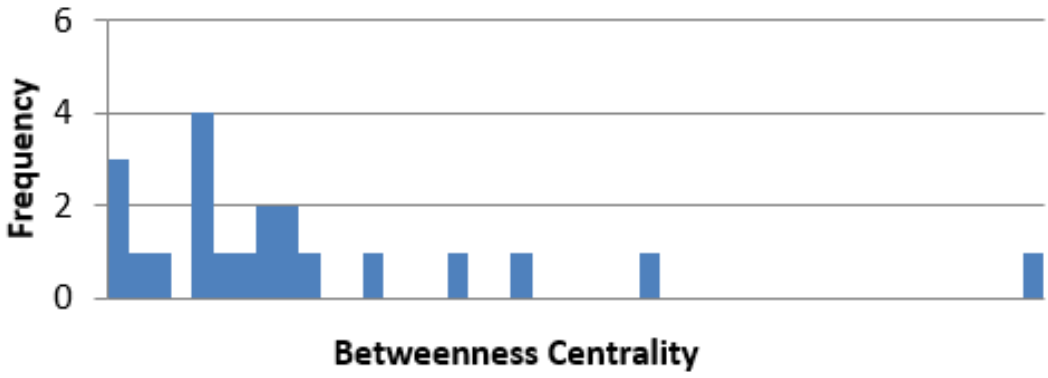
Minimum Eigenvector Centrality	0,019
Maximum Eigenvector Centrality	0,067
Average Eigenvector Centrality	0,040
Median Eigenvector Centrality	0,040

Figure C1.3: Eigenvector Centrality – intended information flow

Table C1.1: Centrality scores per participant – Intended information flow

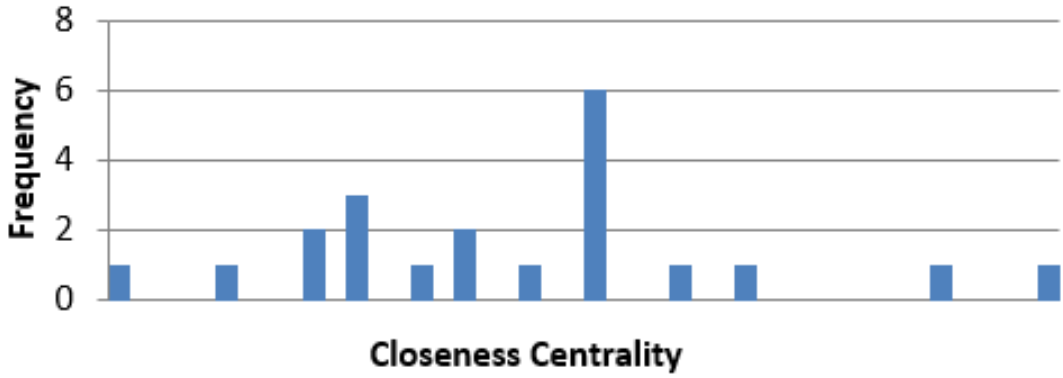
Participant number	Degree Centrality	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1. PM	15	9,1	0,030	0,047
2. PE	21	8,5	0,037	0,061
3. CM	18	5,8	0,033	0,059
4. MFAB	20	10,2	0,040	0,036
5. FOG (c)	16	4,5	0,031	0,067
6. FO (c#1)	12	2,5	0,028	0,045
8. FOG (w)	16	4,5	0,031	0,056
9. FO (w#1)	10	0,3	0,026	0,040
11. ILE	8	0,7	0,025	0,030
12. HIN	12	3,5	0,028	0,043
13. SUP	8	1,0	0,025	0,027
14. FO (i)	13	3,2	0,029	0,043
15. QCE	10	1,3	0,026	0,033
16. QCI	13	1,7	0,029	0,046
17. PL	12	1,1	0,026	0,036
18. PN #1	19	5	0,034	0,056
20. LGF	10	1,2	0,026	0,036
21. LGM	11	1,5	0,027	0,039
22. ASM	6	0,3	0,024	0,022
23. DE	6	0.3	0,024	0,021
24. DEM	5	0,1	0,023	0,019
25. DIR	7	0,6	0,024	0,027
26. DRDE	5	0,1	0,23	0,019
27. DR	5	0,1	0,023	0,019
28. MSHE	19	9	0,034	0,054

Appendix C2 – Centrality measures actual information flow



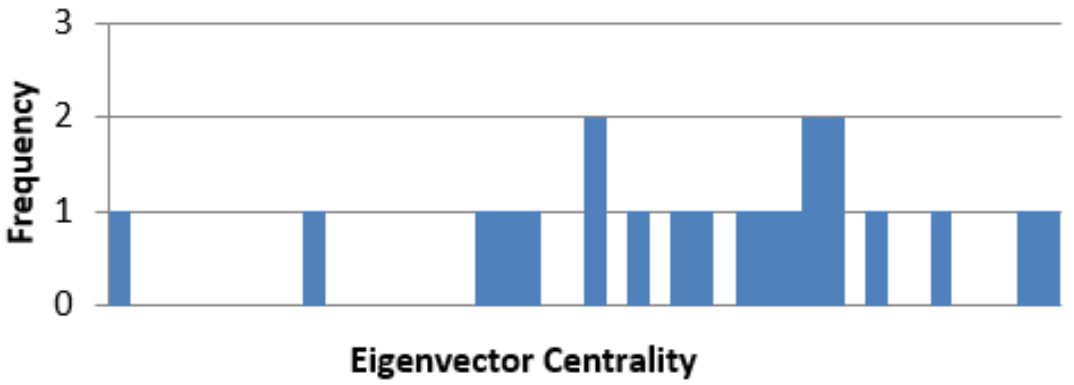
Minimum Betweenness Centrality	0,417
Maximum Betweenness Centrality	14,038
Average Betweenness Centrality	3,333
Median Betweenness Centrality	2,324

Figure C2.1: Betweenness centrality scores – actual information flow



Minimum Closeness Centrality	0,029
Maximum Closeness Centrality	0,050
Average Closeness Centrality	0,038
Median Closeness Centrality	0,038

Figure C2.2: Closeness centrality scores – actual information flow



Minimum Eigenvector Centrality	0,016
Maximum Eigenvector Centrality	0,066
Average Eigenvector Centrality	0,048
Median Eigenvector Centrality	0,050

Figure C2.3: Eigenvector Centrality – actual information flow

Table C2.1: Centrality scores per participant – Actual information flow

Participant number	Degree Centrality	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1. PM	13	4,6	0,034	0,039
2. PE	18	7,1	0,037	0,047
3. CM	18	6,3	0,048	0,065
4. MFAB	20	10,5	0,050	0,066
5. FOG (c)	17	4,5	0,043	0,060
6. FO (c#1)	15	3,1	0,040	0,054
7. FO (c#2)	11	0,6	0,040	0,054
8. FOG (w)	17	6,1	0,042	0,057
9. FO (w#1)	11	0,5	0,034	0,042
10. FO (w#2)	13	0,6	0,034	0,042
11. ILE	7	0,3	0,031	0,028
12. HIN	14	4,4	0,040	0,050
13. SUP	8	0,9	0,029	0,016
14. FO (i)	16	4,9	0,040	0,052
15. QCE	12	1,1	0,036	0,044
16. QCI	13	1,5	0,037	0,048
17. PL	14	1,9	0,038	0,052
18. PN #1	16	4,0	0,040	0,054
19. PN #2	14	1,4	0,040	0,054
20. LGF	11	2,0	0,033	0,036
21. LGM	8	0,6	0,033	0,038

APPENDIX D: VISUALISATION SNA RESULTS

Table D1: Overview of figures in appendix D	
Figures	**Title**
Figure D1	Low responsiveness scores
Figure D2	High responsiveness scores
Figure D3	Low effectiveness scores
Figure D4	High effectiveness scores
Figure D5	Low energy scores
Figure D6	High energy scores
Figure D7	Low willingness to share scores
Figure D8	High willingness to share scores
Figure D9	Low task interdependence scores
Figure D10	High task interdependence scores

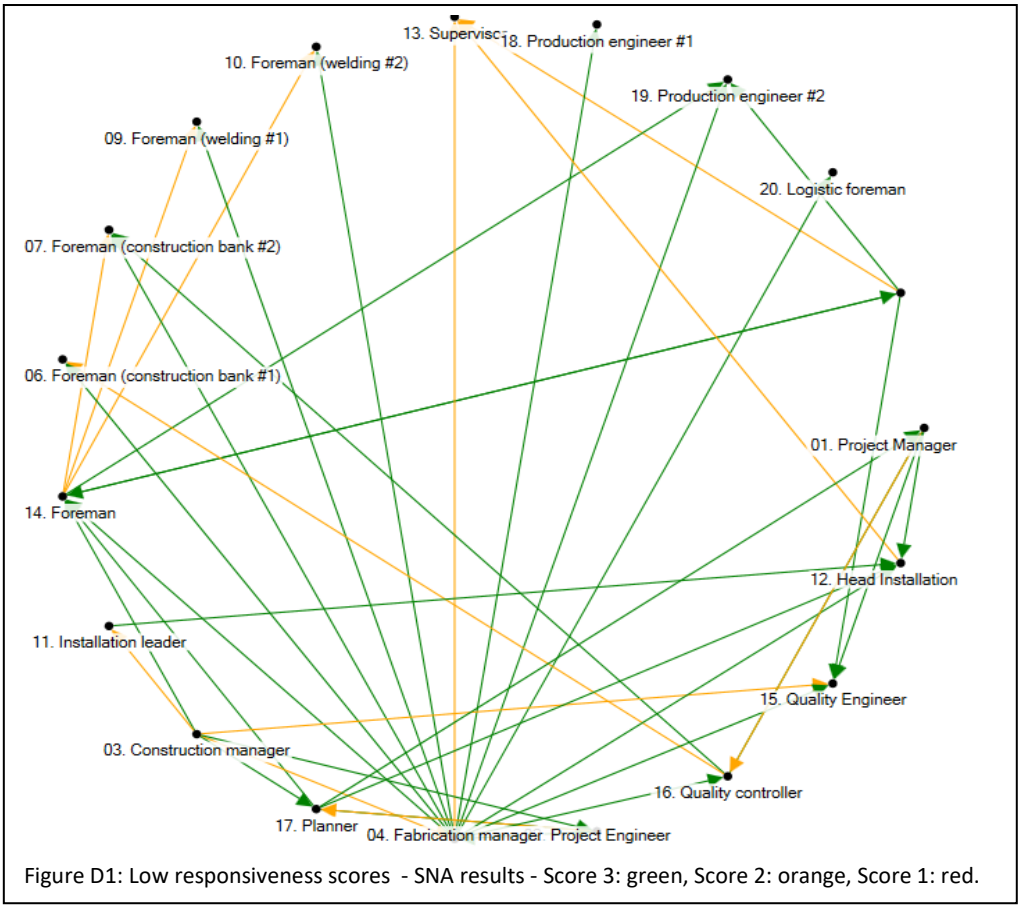


Figure D1: Low responsiveness scores - SNA results - Score 3: green, Score 2: orange, Score 1: red.

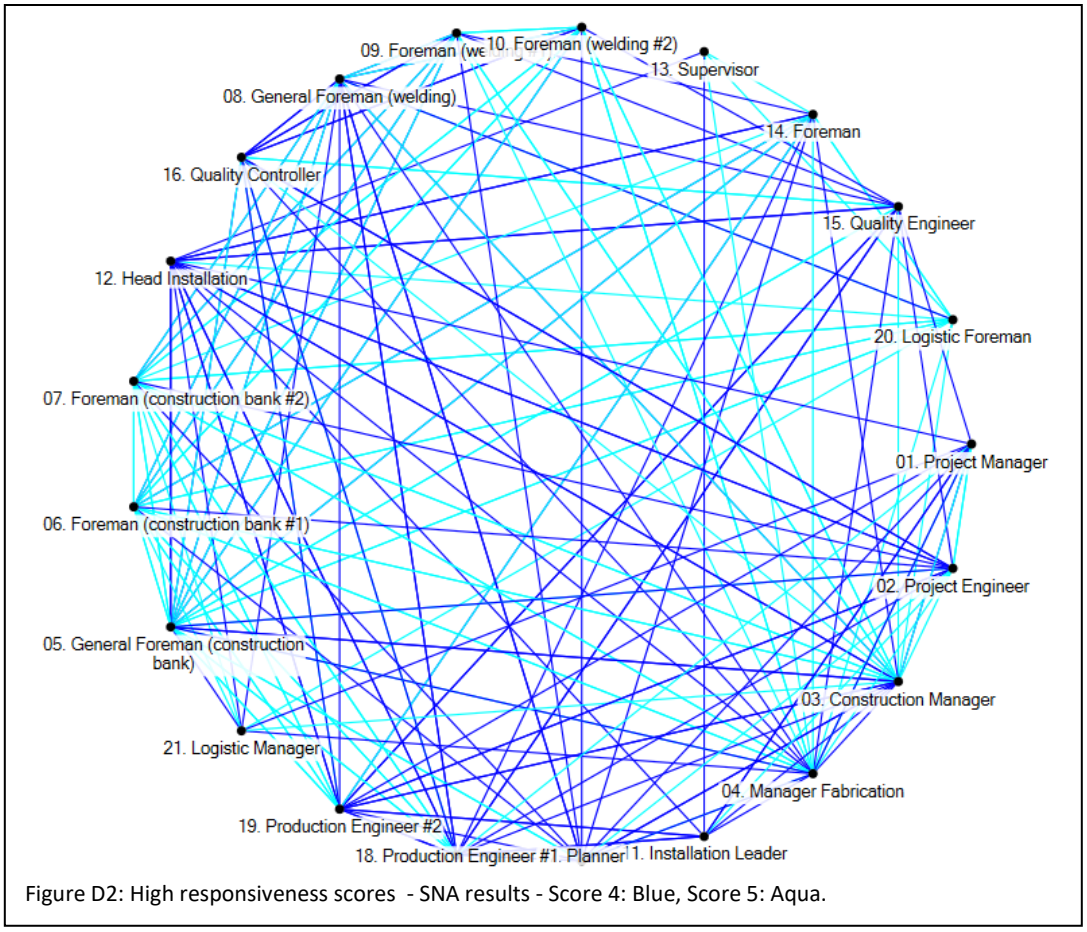


Figure D2: High responsiveness scores - SNA results - Score 4: Blue, Score 5: Aqua.

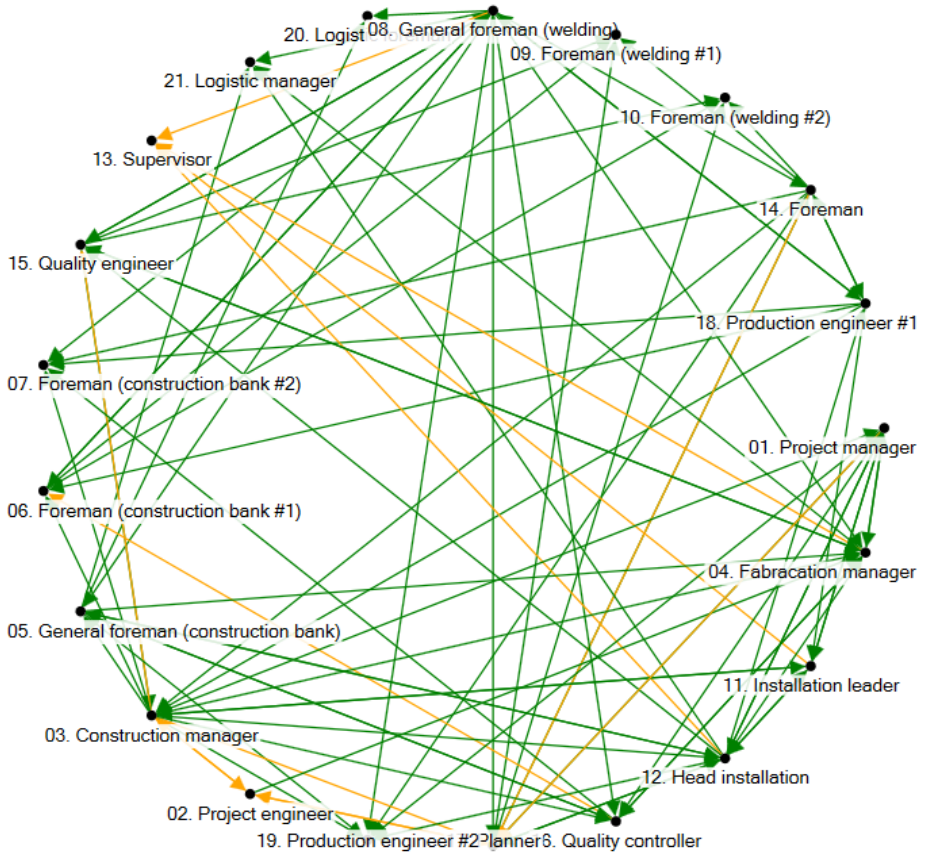


Figure D3: Low effectiveness scores - SNA results - Score 3: green, Score 2: orange, Score 1: red.

Figure D4: High effectiveness scores - SNA results - Score 4: Blue, Score 5: Aqua.

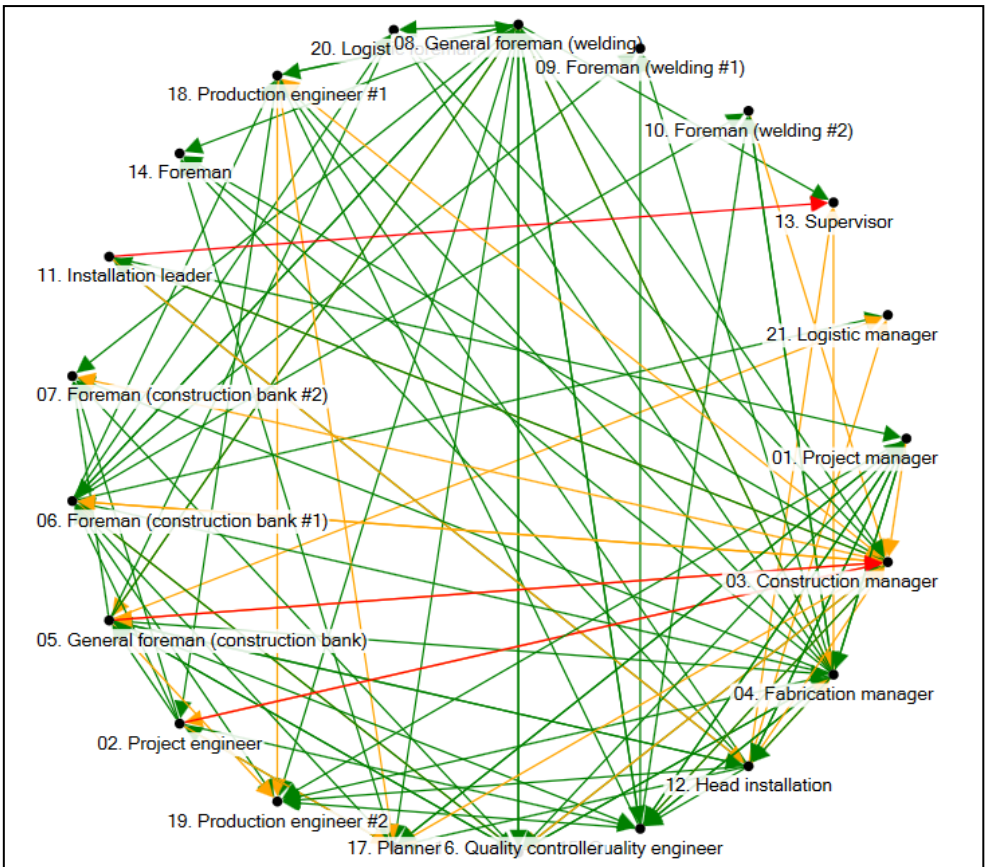


Figure D5: De-energizing scores - SNA results - Score 3: green, Score 2: orange, Score 1: red.

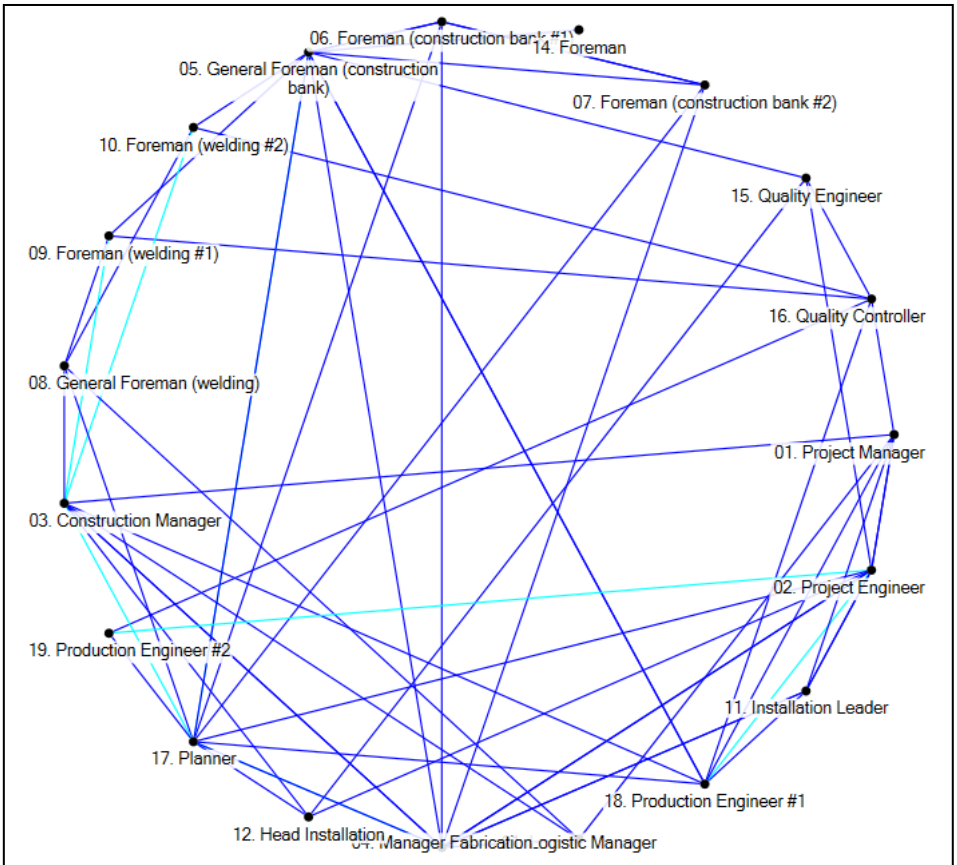


Figure D6: Energizing scores - SNA results - Score 4: Blue, Score 5: Aqua.

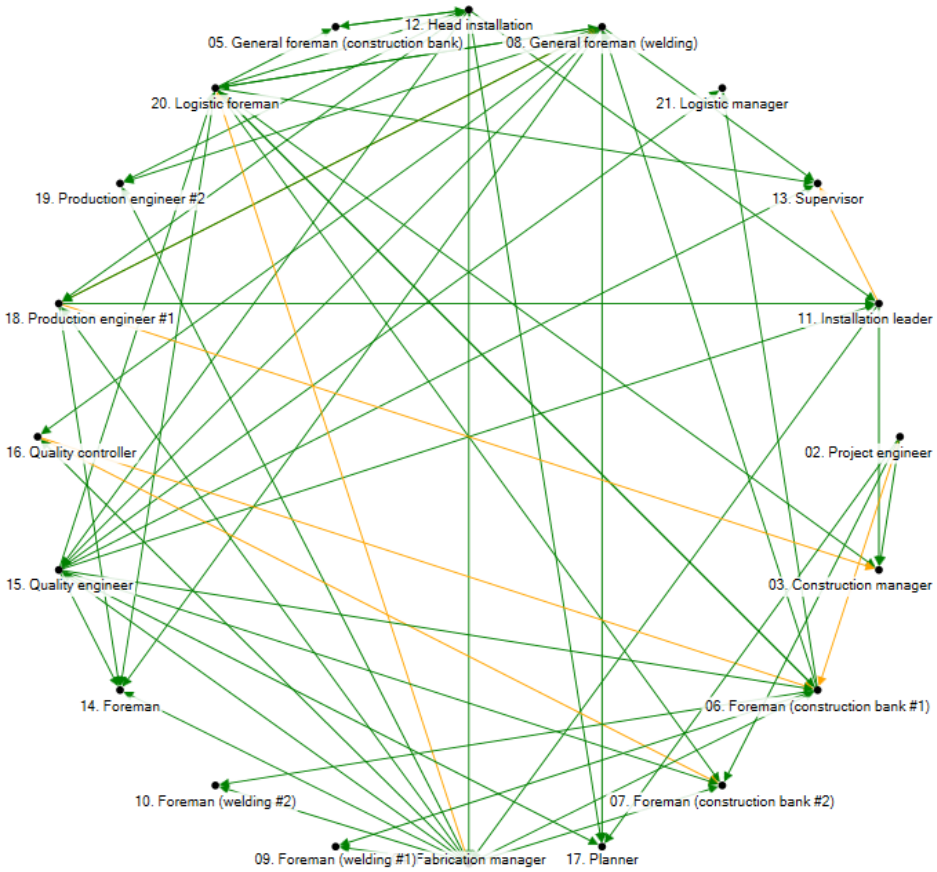


Figure D7: Low Willingness to Share scores - SNA results - Score 3: green, Score 2: orange, Score 1: red.

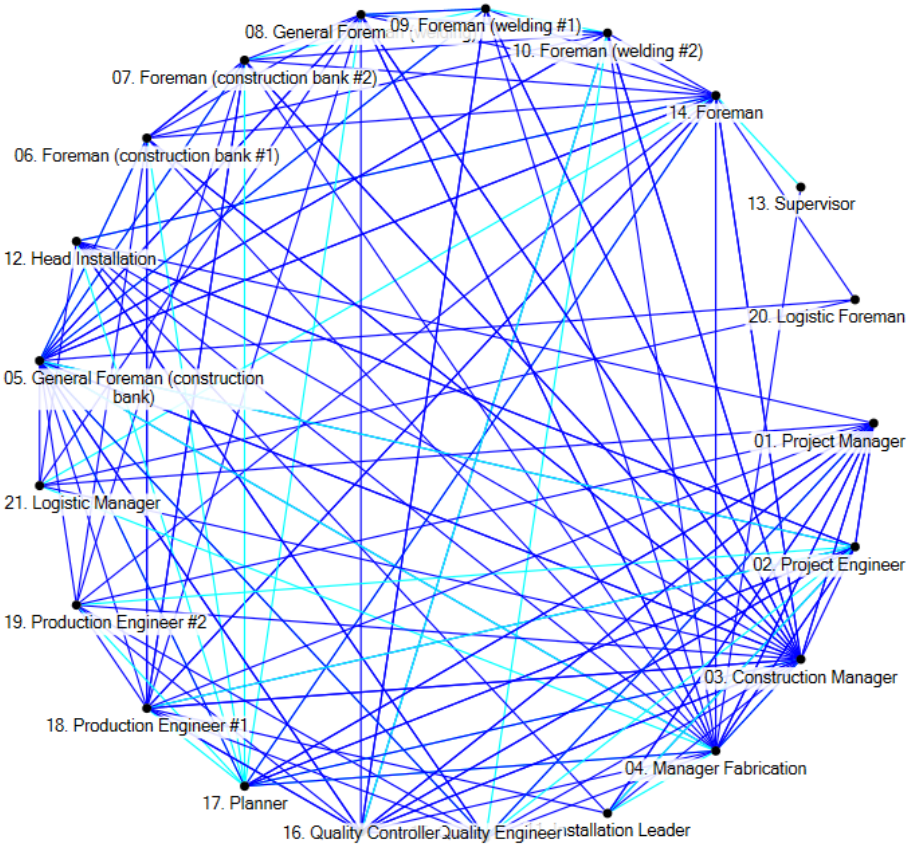


Figure D8: High Willingness to Share scores - SNA results - Score 4: Blue, Score 5: Aqua.

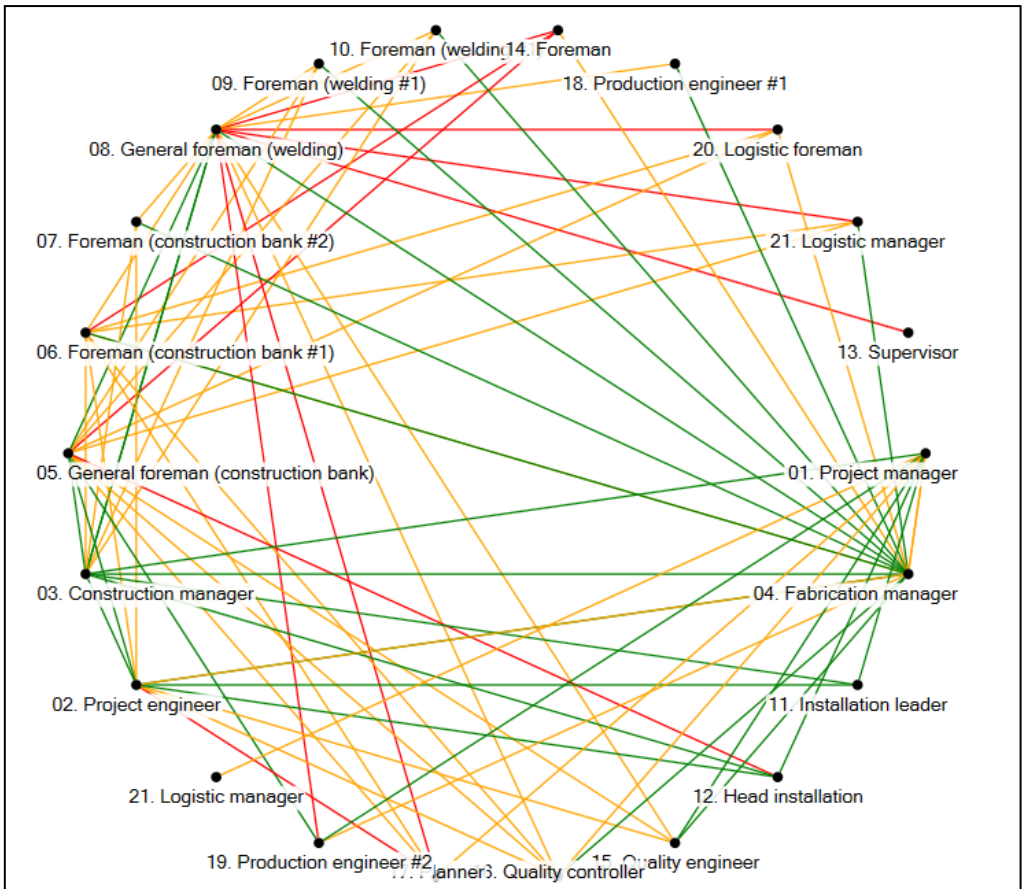


Figure D9: Low Task Interdependence scores - SNA results - Score 3: green, Score 2: orange, Score 1:

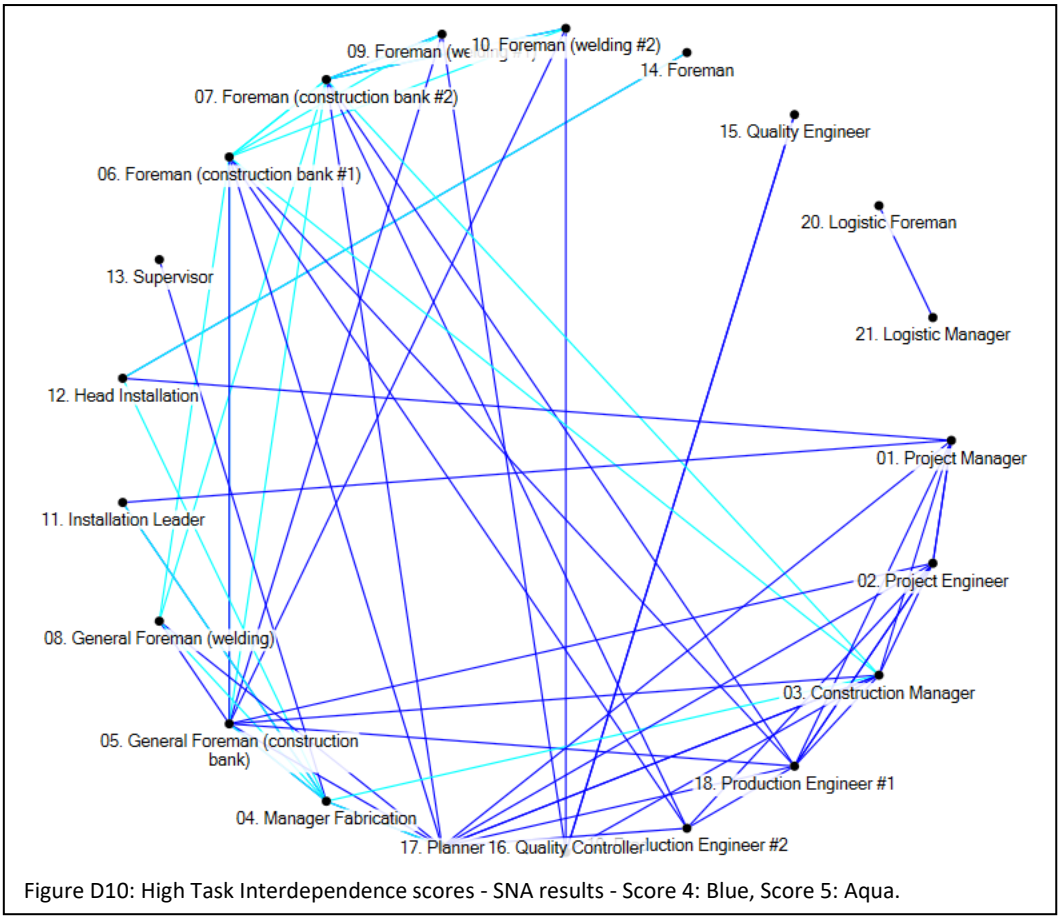


Figure D10: High Task Interdependence scores - SNA results - Score 4: Blue, Score 5: Aqua.

APPENDIX E: AVERAGE SCORES SNA STUDY

Table E1: Calculation of average SNA scores of the Project Manager (PM)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
02.	5	5	4	4	4
03.	4	3	4	4	3
04.	4	3	3	4	2
11.	4	3	3	4	4
12.	4	3	3	4	4
15.	4	4	3	5	3
16.	3	4	3	4	2
17.	3	3	3	4	4
21.	4	3	4	4	4
Average	3,89	3,44	3,33	4,10	3,33

Table E2: Calculation of average SNA scores of the Project Engineer (PE)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	5	4	4	4	4
03.	3	2	2	4	4
04.	4	4	4	4	3
11.	3	4	4	4	3
15.	4	1	4	5	3
16.	4	4	4	4	3
17.	3	4	3	4	4
18.	4	2	3	4	4
19.	4	4	3	4	4
21.	4	3	4	4	4
Average	3,78	3,44	3,56	4,11	3,56

Table E3: Calculation of average SNA scores of the Construction Manager (CM)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	5	4	2	4	4
02.	5	2	1	3	3
04.	5	4	4	5	5
05.	5	4	1	4	4
06.	5	4	2	4	5
07.	5	4	2	4	5
11.	4	3	2	3	2
12.	4	4	2	4	3
15.	5	3	2	4	3
16.	5	4	3	4	3
17.	4	4	5	5	3
18.	4	3	2	2	4
19.	4	3	2	2	3
20.	5	3	3	3	3
21.	4	3	4	4	4
Average	4,56	3,50	2,56	3,81	3,44

Table E4: Calculation of average SNA scores of the Fabrication Manager (MFAB)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	4	3	3	4	2
02.	3	3	4	4	2
03.	2	3	4	4	3
05.	4	3	3	4	4
06.	5	4	4	4	2
07.	5	4	4	4	2
08.	4	3	2	4	3
09.	5	4	3	4	3
10.	5	4	3	4	3
11.	4	4	4	3	4
12.	4	3	2	3	3
13.	3	3	2	3	3
14.	5	4	3	4	3
15.	4	3	3	4	2
16.	4	3	3	4	2
17.	5	4	5	5	4
18.	3	3	3	3	3
19.	3	3	3	4	3
20.	5	3	3	3	3
21.	4	3	4	4	4
Average	4,13	3,33	3,33	3,87	2,93

Table E5: Calculation of average SNA scores of the General Foreman (construction bank) (FOG (c))					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	4	3	2	4	3
06.	5	4	4	5	5
07.	5	3	4	5	5
08.	4	3	2	4	4
09.	4	3	3	3	3
10.	4	3	3	3	3
12.	4	3	3	3	1
14.	4	4	3	4	3
15.	5	4	4	5	3
16.	4	3	3	4	3
17.	5	4	5	5	4
18.	5	4	4	4	2
19.	5	4	4	4	2
20.	5	3	3	3	3
21.	4	3	4	4	4
Average	4,46	3,54	3,38	4,23	3,31

Table E6: Calculation of average SNA scores of the Foreman construction bank #1 (FO c#1)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	5	3	2	4	2
04.	3	4	3	3	3
05.	3	4	3	3	3
07.	4	3	3	4	4
08.	4	3	3	4	2
09.	3	3	3	3	2
10.	3	3	3	4	2
14.	4	4	3	4	2
16.	2	2	2	2	2
17.	4	4	4	5	4
18.	5	3	3	4	2
19.	4	3	3	4	3
20.	5	3	3	3	3
21.	4	4	4	4	4
Average	4,09	3,36	3,09	3,55	2,73

Table E7: Calculation of average SNA scores of the Foreman construction bank #2 (FO c#2)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	5	3	2	4	2
04.	3	4	3	3	3
05.	3	4	3	4	3
06.	5	3	4	4	4
08.	4	3	3	4	2
09.	4	3	3	3	3
10.	4	3	3	3	3
14.	2	4	3	4	2
16.	3	2	3	3	2
18.	5	3	3	2	2
19.	5	3	3	4	2
20.	5	3	3	3	3
21.	4	3	4	2	4
Average	4,08	3,36	3,17	3,67	2,92

Table E8: Calculation of average SNA scores of the General Foreman (welding) (FOG (w))					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	5	4	4	4	3
04.	5	4	3	4	5
05.	5	4	3	4	3
06.	5	3	3	3	5
07.	5	3	3	3	5
09.	4	4	3	5	4
10.	4	4	3	5	4
13.	2	3	2	3	2
14.	3	4	3	4	2
15.	4	3	3	5	3
16.	4	4	3	3	3
17.	4	4	4	5	4
18.	4	3	3	2	2
19.	4	3	2	2	2
20.	5	3	3	3	3
21.	4	3	4	4	4
Average	4,33	3,58	3,00	3,92	3,42

Table E9: Calculation of average SNA scores of the Foreman welding #1 (FO w#1)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	5	4	5	4	2
04.	3	4	3	3	3
05.	3	4	3	3	2
06.	5	4	4	4	2
07.	5	3	3	3	5
08.	5	3	2	4	4
10.	5	4	3	5	4
16.	4	3	3	4	3
Average	4,18	3,55	3,27	3,82	3,00

Table E10: Calculation of average SNA scores of the Foreman welding #2 (FO w#2)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	5	4	5	4	2
04.	3	4	3	3	3
05.	3	3	3	3	2
06.	5	4	4	4	2
07.	4	3	3	4	5
08.	5	3	2	4	4
09.	5	4	3	5	4
16.	4	3	3	4	3
Average	4,10	3,50	3,60	3,70	3,00

Table E11: Calculation of average SNA scores of the Installation Leader (ILE)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	4	3	4	4	3
02.	5	4	4	5	3
03.	2	3	3	4	3
04.	5	4	4	5	5
12.	4	3	3	3	3
13.	2	3	3	3	3
16.	3	4	4	3	1
Average	4,00	3,32	3,61	3,85	3,14

Table E12: Calculation of average SNA scores of the Head of Installation (HIN)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	3	3	3	4	3
02.	4	4	4	4	3
03.	4	3	4	4	3
04.	3	4	3	4	5
05.	4	3	3	3	1
11.	3	3	2	4	3
13.	3	3	3	3	3
14.	5	4	3	5	4
15.	4	3	3	4	2
17.	3	3	4	5	3
18.	4	4	3	4	2
19.	4	4	3	4	2
21.	4	3	4	4	4
Average	3,83	3,08	3,00	4,00	3,00

Table E13: Calculation of average SNA scores of the Supervisor (SUP)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
04.	2	2	2	4	4
08.	3	2	3	3	1
11.	2	2	1	2	3
12.	2	2	2	4	3
14.	4	4	3	5	3
20.	5	3	3	3	3
21.	4	3	4	4	4
Average	3,14	2,67	2,83	3,83	3,00

Table E14: Calculation of average SNA scores of the Foreman Installation (FO)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	3	4	3	4	3
04.	3	4	3	3	2
05.	5	4	4	4	1
06.	5	4	3	3	1
07.	5	4	3	3	1
08.	3	3	3	3	1
09.	3	3	2	3	1
10.	3	3	3	3	1
12.	4	4	3	4	5
13.	3	3	2	4	2
17.	3	3	3	5	1
18.	4	3	3	3	3
19.	4	3	2	4	1
20.	5	3	3	3	3
21.	4	3	4	4	4
Average	3,90	3,50	2,90	3,60	2,40

Table E15: Calculation of average SNA scores of the Quality Engineer (QCE)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	3	4	3	4	3
02.	4	4	3	4	2
03.	2	2	3	4	4
04.	3	3	3	3	3
05.	5	4	3	4	2
08.	3	3	3	3	2
09.	3	3	3	3	3
10.	3	3	4	3	3
12.	4	3	3	4	3
16.	5	4	3	4	4
18.	4	4	3	3	3
21.	3	3	4	4	4
Average	3,70	3,40	3,20	3,70	3,00

Table E16: Calculation of average SNA scores of the Quality Controller (QCI)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	2	3	3	4	2
02.	5	4	4	4	2
03.	4	3	2	4	3
04.	3	3	3	3	3
05.	5	3	2	4	2
06.	3	3	3	3	2
07.	3	3	3	3	2
08.	4	3	2	3	2
09.	3	4	2	4	2
10.	5	4	4	4	4
15.	5	4	4	5	4
18.	5	4	3	4	3
19.	5	4	3	4	3
21.	4	3	4	4	4
Average	4,20	3,40	2,80	3,90	2,90

Table E17: Calculation of average SNA scores of the Planner (PL)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	4	2	3	4	2
02.	2	2	2	2	1
03.	3	2	2	4	4
04.	4	4	4	4	5
05.	5	5	4	4	2
06.	5	4	3	3	2
07.	4	3	3	3	2
08.	4	3	3	3	1
09.	4	4	3	3	1
10.	4	3	3	3	1
12.	4	3	3	3	2
14.	5	2	3	4	2
18.	3	3	4	3	1
19.	4	3	2	4	2
Average	4,00	3,00	3,11	3,56	2,56

Table E18: Calculation of average SNA scores of the Production Engineer #1 (PN #1)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
02.	5	4	4	4	4
03.	4	5	5	5	4
04.	4	4	2	4	4
05.	3	4	3	3	3
06.	5	5	4	4	4
07.	5	4	3	4	4
08.	5	3	3	4	2
11.	4	4	4	3	2
12.	4	3	3	4	1
14.	4	3	3	3	2
15.	4	4	3	4	2
16.	3	4	4	4	3
17.	4	4	4	5	4
19.	4	3	4	4	4
Average	4,14	3,86	3,50	3,93	3,07

Table E19: Calculation of average SNA scores of the Production Engineer #2 (PN #2)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
02.	5	4	4	4	4
03.	4	5	5	5	4
04.	4	4	2	4	4
05.	3	4	3	3	3
06.	5	5	4	4	3
07.	4	4	2	4	3
08.	5	2	3	4	2
11.	4	4	4	3	2
12.	4	3	3	4	1
14.	5	3	3	3	2
15.	4	4	3	4	2
16.	3	4	3	4	3
17.	3	3	4	5	3
19.	4	3	4	4	4
Average	4,00	3,36	3,36	3,93	2,71

Table E20: Calculation of average SNA scores of the Logistic Foreman (LGF)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
03.	5	4	3	4	2
04.	3	4	3	2	2
05.	5	3	3	4	2
06.	5	4	3	3	2
07.	5	4	3	3	2
08.	4	3	3	3	1
12.	4	4	2	4	2
13.	3	3	2	4	2
14.	5	4	3	3	3
21.	4	3	3	4	4
Average	4,43	3,57	2,75	3,38	2,13

Table E21: Calculation of average SNA scores of the Logistic Manager (LGM)					
	Responsiveness	Effectiveness	Energy	Willingness to Share	Task Interdependence
01.	4	4	2	4	2
02.	4	3	3	3	3
03.	5	5	4	4	3
04.	4	3	3	4	2
05.	4	3	2	3	2
06.	5	4	3	4	2
07.	5	4	3	4	1
08.	4	3	4	4	1
12.	4	3	2	4	3
13.	3	3	2	3	2
14.	5	4	3	5	1
20.	5	4	3	4	4
Average	4,44	3,67	2,90	3,90	2,40

APPENDIX F: INTERVIEW – ABSENT AND UNFORESEEN CONTACT MOMENTS

The questions below are posed to the actors who have absent contact moments and/or unforeseen contact moments with other actors. These interviews were conducted in an informal way, but help to better understand the reason behind the differences found between the intended and actual information flow. Next to this, the opinion related questions provide insight what the workforce considers to be important when it comes to using informal information flows to enhance coordination. The results of these interviews were verified by the interviewee afterwards. They agreed with the conclusions drawn.

Absent contact moments

The questions below were asked to the actors who were expected to have certain contact moments with other actors, but did not according to the SNA results.

Question 1: Why are the expected contact moments with X absent according to the SNA results?

Question 2: What kind of information is in danger of not being passed on properly?

Question 3: Is this missing flow of information now captured in a different way?

Question 4: What is your personal opinion on this missing absent moment?

Unforeseen contact moments

The questions below were asked to the actors who were not expected to have certain contact moments with other actors, but did according to the SNA results.

Question 1: Why are the unexpected contact moments with X present according to the SNA results?

Question 2: Are these unexpected contact moments with X necessary for you to get all your necessary information together?

Question 3: Suppose these contact moments did not take place after all, would this have consequences for you with regard to your information gathering?

Question 4: What is your personal opinion on this missing absent moment?

Centrality scores related questions

The questions below were asked to the actors who are involved in differences emerging from the quantitative analysis. Different actors got different questions fitting to their role.

Project manager / Project engineer

Question 1: The SNA shows that all contact with the workforce in the installation hall is missing. As a result, your role ends up in a less central position as was originally intended. Is this a problem for you as project manager when doing your job?

Question 2: Would you say this needs to be changed?

Manager of fabrications

Question 1: The quantitative analysis shows that the role of manager of fabrications is the most central role in the network, which is confirmed by the SNA. Do you experience that this role is too centrally located?

Question 2: Given the central position, are you still able to do your job?

Question 3: Would you say that you experience pressure from your work, which could lead to, for example, burnout complaints?

Opinion on how information flows can be enhanced

Question 1: What factors are crucial for you to maintain or improve the information flow within Hollandia Infra?

Question 2: How is your willingness to share information influenced by your colleagues?

Question 3: Would you consider your role as a well-integrated part of the overall process, and if not what could be improved?

All interviewees are offered to provide further comments.

APPENDIX G: INTERVIEW FINDINGS

The interview findings can be found in table G1.

Table G1: Interview findings ***Absent contact moments related questions***		
Role	***Absent contact moment with:***	***Conclusions drawn from interview questions***
Project Manager	Supervisor	• Is informed through the project engineer at a later state in the project; • Contact is not necessary.
	Logistic Foreman	• The project manager hardly visits the construction hall; • The project manager receives logistic related information from the logistic manager. This makes contact moments with the logistic foreman irrelevant.
Project Engineer	Supervisor	• This has to do with phasing. This contact will be present in a later state of this project;
Logistic Foreman	Project Manager	• The Logistic foreman hardly goes into the office; • The Logistic Manager informs the project manager about logistic related information.
Unforeseen contact moments related questions		
Role	***Unforeseen contact moment with:***	***Conclusions drawn from interview questions***
Project engineer	Quality Engineer	• Contact is especially strong in the initial phase; • The quality engineer has information that needs to be implemented in the construction drawings; • Once in production there is contact if an error is made; • These informal contact moments are crucial in the overall process.
Construction Manager	Quality Engineer	• Contacts the quality engineer to find out what else is needed to get the construction through production; • These contact moments provide additional information that is crucial for the process.
	Logistic Foreman	• Construction manager finds it valuable to update the logistic foreman when certain products are finished; • The foreman informs more effective compared to other roles.
Quality Engineer	Project Engineer	• The quality engineer contacts the project engineer when questions arise because something is not understood from a construction drawing; • The quality engineer contacts the project engineer when something deviates from what was asked;

		• The project engineer has the most insight into technical and mechanical problems, which means this is often the shortest way to get information; • This contact seems to be of high importance, since no other roles can answer arising questions as well as the project engineer.
	Construction Manager	• The quality engineer is uncertain about the meaning of the role of construction manager; • The construction manager more often contacts the quality engineer as its goal is to get the construction through production as quickly as possible.
Planner	Foreman (construction bank #1)	• Contacts the foreman to gain insight in the progress of the project; • Contacts the foreman to find norms to be able to test how long something may take; • The planner would rather hear this information from the foreman himself than from, for instance the manager of fabrication; • Information could be retrieved through other actors as well, but consulting the foreman is quicker.
	Head of Installation	• Planner contacts the Head of Installation to gain insight in what capacity is needed; • This information could also be retrieved from the Installation Leader, but the head of installation is on location and is thus better informed.
Logistic Foreman	Construction Manager	• The construction manager is responsible for anything that happens to the product until it is finished, therefore the construction manager wants to be kept informed by the logistic manager about the complex transport movements.
Head of Installation	Planner	• The head of installation works on location. He likes to keep a short line with the planning to monitor the progress of the project; • The head of installation also provides input on the planning schedule when activities take less or more time than initially thought.
Foreman (construction bank #1)	Planner	• The foreman has a close relationship with the general foreman. They often talk together with the planner, even though his position does not require it.
Centrality scores related questions		
Role	***Centrality score difference***	***Conclusions drawn from interview questions***
Project manager	SNA shows a less central score in comparison with the intended network.	• Willing to invest in having more contacts with the workforce of the installation hall; • Claims to have no time for these contacts with the workforce in the production hall;

		• States that these contacts would be an improvement for the overall coordination.
Project engineer	SNA shows a less central score in comparison with the intended network.	• Claims no contact with the foremen related to welding is necessary; • Contact with the supervisor will occur in a later stage; • Suggests that the role of the foremen gets added in the formal process.
Manager of fabrications	SNA confirms the central role of the intended network.	• Confirms the role is overloaded; • Role should be less central; • This role should not be executed by the same person for years on end.

Opinion on informal information flow and coordination related questions

Conclusions drawn from interview questions

Crucial factors to maintain or improve informal communication with colleagues:

- Actually meeting and talking to each other (is not as common as one may think);
- Consciously taking the time for each other;
- That there are short lines in terms of contact and e-mail should not be necessary;
- Informal information is experienced as more pleasant than formal;
- Hierarchy should not be there in streamlining communication. Everyone should be able to ask questions.

Crucial factors to maintain or improve the willingness to share information:

- Mutual feeling of trust;
- Knowing colleagues personally, team building;
- Getting the feeling that someone takes time for you;
- No blame culture;

Crucial factors to improve the level of how well one role is integrated:

- The planner should have a more integrated role;
- The planner should have more contact moments with the project engineer;
- The quality engineer feels he is not informed well;
- The quality engineer is disappointed that quality engineering is not included in the planning;
- The project engineer is informally well integrated in the process;
- The project engineer is formally less integrated in the process, due to the fact that there is no direct line to production. There is also no direct contact with installation. Some facets are underexposed.

Other comments from the interviewees:

- The major investment in the social aspect of the organisation and its informal information flows comes with a neglect of the developments linked to the formal information flow. The formal information flow is no longer up to date and it can be hard to draw the right information from it.

APPENDIX H: EXPERT INTERVIEWS

In this appendix:

- Appendix H1: Expert meeting with a board member on the organisation structure;
- Appendix H2: Expert meeting with the director of Hollandia Infra;
- Appendix H3: Expert meeting with a board member.

Appendix H1 – Board member on the organisation structure

Date	:	31-05-2021
Interviewer	:	Tom Oorschot
Function interviewee	:	Board member (Project buyer)

The conclusions drawn from the interview are given in this appendix. They are based on recordings of the interview and have later be verified by the expert that was interviewed. This way the chance of wrong interpretations by the interviewer are reduced.

Validation of the choices of the primary process

The expert validates that the identified primary process steps of engineering, production and installation are most important when studying the construction phase.

- The expert states that especially engineering should not be forgotten as they are often needed during production;
- The expert states that quality engineers play a vital role in the process between engineering and production.

Validation of the choices of the supporting processes

The expert validates that the identified supporting processes of quality control, production engineering and coordinating conservation are most important when studying the construction phase.

- The expert states that quality control is a highly valued discipline within Hollandia Infra and should definitely be included;
- The expert states that the marketing/purchase department is not important for this particular phase;
- The expert states that the logistic manager and foreman have communication links with engineering during this phase. Therefore it is important to include ‘coordinating conservation’.

Validation on table 3.1 – the intended information flow

The intended information flow as delivered by the researcher has been extensively and thoroughly checked. The expert validates that the visualisation of the intended information flow is correct.

- The transformation of process diagrams from Hollandia to this visualization provides a clear overview of the communication between actors;

Appendix H2 – Director of Hollandia Infra

Date	:	24-08-2021
Interviewer	:	Tom Oorschot
Function interviewee	:	Director

The conclusions drawn from the interview are given in this appendix. They are based on recordings of the interview and have later be verified by the expert that was interviewed. This way, the chance of wrong interpretations by the interviewer are reduced.

Validation of managerial implications

The expert agrees with the identified managerial implications and thereby completes the validation. Each managerial implication is stated below including the conclusions drawn from the interview with the expert.

1. ***The project manager must maintain frequent contact with the workforce in the production hall.***

The expert states:

- It is very important for a project manager to have contact with the workforce. This improves the connection the project manager has with the project;
- The managerial implications is very recognisable and should definitely be applied;
- The expert acknowledges that project managers have very loaded jobs. Still, time must be set aside for this development.

2. ***The role of manager of fabrication must be less central in order to prevent a burn out.***

The expert states:

- The role of the manager of fabrications is indeed very central during the construction phase;
- The position of this role should indeed be a bit less central. This could be achieved by centralising the role of the project manager;
- The expert states that this managerial implication is very important and should be applied.

3. ***The formal process must distinguish between different foremen roles.***

The expert states that:

- The expert is surprised that this distinction is not there;
- This distinction should certainly be made. Especially given the fact that there are even more different foremen roles that are not described in this particular project;

4. ***Focus on a relationship-oriented approach.***

The expert states that:

- A relationship-oriented approach is the best way to achieve results;
- Recognises and agrees with this managerial implication;
- States that this is his management style, which he tried to introduce when stationed.

5. *Involve roles early on in the project.*

The expert states that:

- Acknowledges that this is an important managerial implications;
- However, given that this managerial implications came forward from the aspect of task interdependence, the expert is negative its chance of success;
- States that involving roles early on in the project will increase the involvement of the actors in the project.

6. *Create awareness on everyone's role and position.*

The expert states that:

- The expert is slightly shocked that some actors don't really know what all the other roles entail;
- States that this managerial implication is very recognisable, but adds that it is also the responsibility of each actor to know exactly what other roles do;

7. *Replace central actors with care.*

The expert states that:

- Admits and recognizes that this is indeed an important aspect;
- Adds that it is not always easy in practice. Civil engineering has a shortage of skilled people. This means that sometimes you have to take the best you can get.

8. *Invest in awareness on energizing one another.*

The expert states that:

- The expert considers this a very important managerial implication given the outcome of the SNA;
- Adds that a person's attitude can have a lot of effect on his direct colleagues;

9. *Invest in creating a balance between the formal and informal information flows and the role they should fulfil.*

The expert states that:

- States that in recent years he has invested a lot as director in the development of the informal side;
- Admits that he has invested less in formal development because of this;
- Finds the creation of the right balance between these two important aspects very important. However, this does not seem easy.

10. *Invest in modern technology concerning formal information flows.*

The expert states that:

- The expert certainly believes that investment should be made in this area in the coming period. This also contributes to creating the balance between both factors.

Determination of the most important managerial implications

After thoroughly going through all managerial implications, it was determined which three are the most important for Hollandia Infra. According to the expert, most attention should be focused on:

- MI01: The project manager must maintain frequent contact with the workforce in the production hall.
- MI02: The role of manager of fabrication must be less central in order to prevent a burn out.
- MI09: Invest in creating a balance between the formal and informal information flows and the role they should fulfil.

Appendix H3 – Board member of Hollandia Infra

Date	:	24-08-2021
Interviewer	:	Tom Oorschot
Function interviewee	:	Board member

The conclusions drawn from the interview are given in this appendix. They are based on recordings of the interview and have later be verified by the expert that was interviewed. This way the chance of wrong interpretations by the interviewer are reduced.

Validation of managerial implications

The expert agrees with the identified managerial implications and thereby completes the validation. Each managerial implication is stated below including the conclusions drawn from the interview with the expert.

1. *The project manager must maintain frequent contact with the workforce in the production hall.*

The expert states:

- A good connection with the work force is actually necessary for every project leader. In practice this is clearly not always possible;
- The managerial implications is very recognisable and should definitely be applied.

2. *The role of manager of fabrication must be less central in order to prevent a burn out.*

The expert states:

- The expert states that he finds it worrying that the position of the manager of fabrications is this central. This should not be the case;
- The position of this role should indeed be a bit less central;
- The expert even proposes a dichotomy so that two people become responsible for this position.

3. *The formal process must distinguish between different foremen roles.*

The expert states that:

- This distinction should certainly be made;
- The expert states that he is not a fan of Hollandia's formal processes. He often finds them too extensive.

4. *Focus on a relationship-oriented approach.*

The expert states that:

- States that the current director invested in this when stationed;
- This investment is also the result of the lack in development of the formal information flow;
- This approach has changed and improved the company culture.

5. *Involve roles early on in the project.*

The expert states that:
- Acknowledges that this is an important managerial implications;
- States that involving roles early on in the project will increase the involvement of the actors in the project.

6. *Create awareness on everyone's role and position.*

The expert states that:
- The expert is slightly shocked that some actors don't really know what all the other roles entail;
- States that this managerial implication is very recognisable, but adds that it is also the responsibility of each actor to know exactly what other roles do;

7. *Replace central actors with care.*

The expert states that:
- Admits and recognizes that this is indeed an important aspect;
- Says that the company culture is often already addressed in the application processes to check whether someone is a good fit for the team.

8. *Invest in awareness on energizing one another.*

The expert states that:
- The expert considers this a very important managerial implication given the outcome of the SNA;

9. *Invest in creating a balance between the formal and informal information flows and the role they should fulfil.*

The expert states that:
- Repeats that the director has invested a lot in the informal information flows. As a result, the formal information flow has not been properly developed. Admits that he has invested less in formal development because of this;
- A balance should definitely be created, but for Hollandia this may mean investing more in the development of the formal information flow.

10. *Invest in modern technology concerning the development of formal information flows.*

The expert states that:
- The expert certainly believes that investment should be made in this area in the coming period. This also contributes to creating the balance between both factors.

Determination of the most important managerial implications

After thoroughly going through all managerial implications, it was determined which three are the most important for Hollandia Infra. According to the expert, most attention should be focused on:

- MI01: The project manager must maintain frequent contact with the workforce in the production hall.
- MI02: The role of manager of fabrication must be less central in order to prevent a burn out.
- MI09: Invest in creating a balance between the formal and informal information flows and the role they should fulfil.

Clearly states that if a fourth one should be named it should be:

- MI10: Invest in modern technology concerning the development of formal information flows.